REPORT OF

THE NATIONAL PARK SERVICE MONITORING WORKSHOP: PLANNING FOR THE FUTURE IN THE NATIONAL CAPITAL NETWORK

9-11 July, 2002

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http://www.nature.nps.gov/im/units/nw12/index.html

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Executive Summary

This report summarizes the discussions of the *National Park Service Monitoring Workshop: Planning for the Future in the National Capital Network* hosted by the National Capital Network Inventory and Monitoring Program of the National Park Service. The Monitoring Workshop was a 3-day event held at the National Conservation Training Center, U.S. Fish and Wildlife Service, Shepherdstown, WV, 9-11 July 2002. The event was part of a seven-step process that is being implemented in order to develop a comprehensive long-term monitoring plan for the parks of the National Capital Network (NCN). The workshop's purpose was to: 1. develop partnerships among National Park Service (NPS) divisions, universities, local, state, and federal agencies, non-government organizations, and private individuals in order to monitor and preserve the critical resources throughout the region, and 2. refine the conceptual models that have been developed by the network's Science Advisory Committee (SAC), prioritize threats to key resources, and generate monitoring goals and objectives. The workshop generated information necessary to draft the overview, conceptual models, and vital signs chapters of the NCN Monitoring Plan.

Day one of the workshop focused on providing an overview of the I & M planning process (an agenda for the workshop is included in Appendix A and can be downloaded from the NCN website: http://www.nature.nps.gov/im/units/nw12/monitoringworkshop.html) to participants. Key presentations were given about the region's ecological context, an overview of the national I & M program, and an update on the efforts by this network and the SAC. Breakout sessions focused on developing partnerships to implement monitoring, enhancing park management using sound science, and the role of the I & M program to support interpretation in the parks.

Workgroups focusing on each of the most important resources (as identified by the SAC: air, geology, landscape, invertebrates, rare/threatened/endangered species and communities, vegetation communities, water, and wildlife) met on days two and three of the workshop to review and finalize the conceptual models developed by the SAC. In addition, the workgroups prioritized threats and developed monitoring goals and objectives. Threats were prioritized within each workgroup by using a prioritization matrix. Scores were assigned to each threat using five criteria: area affected, intensity, urgency, feasibility to monitor, and monitoring cost. The scores were averaged among workgroup participants and discussed. Broadly defined monitoring goals and more specific objectives were generated for high priority threats. Some of the workgroups also identified monitoring protocols to most efficiently monitor the resources in the region. The workshop provided several opportunities for participants to network, including a session on the last day in which workgroups presented goals and objectives during a poster session and participants had the opportunity to provide input to the other workgroups. All breakout sessions were professionally facilitated and small workgroup discussions were facilitated by I & M staff, park staff, and professional facilitators.

Overview

Background

The National Park Service is implementing a servicewide Inventory and Monitoring (I & M) program at more than 270 parks organized into 32 networks. The National Capital Network (NCN) is comprised of eleven National Parks, including Antietam National Battlefield, Catoctin Mountain Park, Chesapeake and Ohio Canal National Historical Park, George Washington Memorial Parkway, Harpers Ferry National Historical Park, Manassas National Battlefield Park, Monocacy National Battlefield, National Capital Parks-East, Prince William Forest Park, Rock Creek Park, and Wolf Trap Farm Park, and a segment of the Appalachian Trail stretching from Shenandoah National Park to the Pennsylvania border. In addition, the I & M program supports the efforts of National Capital Parks-Central. These parks cover four physiographic regions, including the Coastal Plain, Piedmont, Ridge and Valley, and Blue Ridge. Most were established for their cultural value, but all contain significant natural features, such as the Potomac Gorge which is considered to be one of the most biologically diverse sites in the country.

The NCN is among the first networks to receive funding to design a comprehensive long-term monitoring plan. The NCN I & M program is developing the plan by following the recommended seven-step approach outlined by the NPS Natural Resources Information Division. The process includes creating a Board of Directors (BOD) and a Science Advisory Committee (SAC), sponsoring a monitoring workshop, soliciting peer review, and writing the Monitoring Plan.

The final Monitoring Plan will contain a series of chapters that will be completed over a period of two years. Chapter II provides an overview of the network parks and environs, including their significant natural resources as identified by the park staff, park Resource Management Plans and General Management Plans, subject matter experts, and the scientific literature. Chapter III presents conceptual models that represent the network's most important natural resources, their threats, and ecological effects of the threats. Chapter IV will present the vital signs or ecological indicators selected by the SAC to monitor the region's ecosystem health. Remaining chapters will include a detailed data management plan, copies of field forms and databases, a discussion of field and analysis protocols, budgets and staffing plan.

Natural Resource Inventories

The I & M program's short-term goals are to inventory vertebrates and vascular plants at each park and to determine relative abundance and distribution for species of concern. A review of existing data in the NCN began in 1999 (TNC 1999) and was expanded in 2000 with field work to fill major information gaps (Gray and Koenen 2001). Inventories will continue until completion expected in 2005. The field research is awarded by competitive contracts or agreements. Volunteers have also been supporting inventories through systematic bird surveys at selected parks in the network. In addition to biological inventories, the I & M program is completing inventories of air quality, base cartography, geologic resources, soils data, vegetation communities, water classification and quality, and meteorological data. These data are being managed centrally and will be incorporated into searchable online databases and geographic information systems that will become essential components to park natural resource management.

Monitor Vital Signs

Long-term goals of the I & M program are to monitor physical and biological resources to better understand the status and trends of the parks' natural resources. Each network is designing a single, integrated program to monitor both physical and biological resources such as air and water, geologic resources, threatened and endangered species, exotic species, and other flora and fauna. The monitoring will provide information essential to preserving and enhancing the region's most important natural resources. Much of this work will be implemented in coordination with partnerships, including neighboring universities, Cooperative Ecosystem Studies Units (CESU), local, state, and federal governmental agencies, and non-profit organizations.

The National Capital Network is following the seven-step process recommended by the National Park Service Resource Information Division.

1. Form a Board of Directors and Science Advisory Committee

    The National Capital Network BOD is composed of 12 superintendents or their designee (assistant superintendent or natural resource manager), the regional I & M coordinator, the monitoring coordinator, and the chief of natural resources and science. The role of the BOD is to provide oversight to the planning process, approve major decisions, including the formation of the SAC, adopt network goals, and approve annual work plans and reports, the final Monitoring Plan, staffing, and budget. A charter was developed to outline procedural matters for the BOD.

    The SAC is composed of 27 participants approved by the BOD: one resource manager from each park, regional NPS staff (botanist, wildlife biologist, exotic plant management team coordinator, integrated pest management coordinator, chief of natural resources and science, and the region's hydrologists), Inventory and Monitoring staff (regional I & M coordinator, monitoring coordinator, biological inventories coordinator, data manager, and biological science technicians), and scientists from partnering agencies (USGS and EPA). In addition, 27 ad-hoc participants were invited to some SAC meetings to provide additional technical expertise, including representatives from USGS, Smithsonian Museum of Natural History, The Nature Conservancy, Department of Defense, Maryland Department of Natural History, District of Columbia Council of Governments, and four universities.

    The SAC has been meeting regularly since fall of 2001 to identify the region's most important natural resources and develop conceptual models for each. The SAC grouped the region's most important resources into eight categories: air, geology, landscape, invertebrates, rare, threatened and endangered (RTE) species and communities, vegetation communities, water resources, and wildlife (vertebrates). Workgroups were established to develop conceptual models for each important resource. Workgroup leaders and facilitators met separately to discuss and resolve overlap issues. The resulting model summarizes resource components, stresses, sources of the stresses, ecological effects of the stresses, and potential vital signs in a table format.

2. Summarize existing data and understanding

Park Summaries: Park-specific descriptions were developed to highlight key natural resources (Appendix C). The summaries also provide an overview of current and past monitoring efforts at each park. The document was generated by reviewing the most recent Resource Management Plans and General Management Plans, Project Management Information System (PMIS) which track proposed and funded projects in each park, and Investigator Annual Reports (IAR) which provide annual summaries for each research project in a park. I & M staff used this background information to develop park-specific questionnaires to determine the status of proposed projects. The questionnaires also helped to identify critical natural resources, management issues, threats, and each park's monitoring needs. In addition, the questionnaires evaluated how inventory and monitoring related data was being managed, analyzed, and reported by the parks. Questionnaires were sent to each park's resource management staff and superintendent. The questions were answered by conducting follow up interviews. The minutes were subsequently summarized and compiled into a single document covering all parks. A synthesis was created from this comprehensive summary, in table format to provide an overview of which issues were important among the parks (Appendix C).

Supplemental park information was summarized for aquatic resources, air resources, and RTE species and communities, and the summaries were provided to the respective workgroups (Appendix C).

Regional Monitoring Efforts: An effort was made to develop a comprehensive understanding of ongoing monitoring programs in the region, covering both biotic and abiotic resources (Appendix C). The I & M team brainstormed with resource managers and superintendents to identify individuals and agencies conducting monitoring programs on lands adjacent to the parks. In addition, internet searches were performed to identify conservation and monitoring programs throughout the region. Telephone interviews were conducted to follow up with representatives from local, state, and federal government and non-government conservation agencies. In a few cases, members of the I & M team performed site visits to get a better understanding of monitoring efforts. Numerous contacts and interviews were accomplished by participating in regional and national conferences such as the Washington Botanical Society, The George Wright Society, The Wildlife Society, including the annual meeting of the Virginia Chapter, a non-native species workshop, Chesapeake Bay Program – Federal Subcommittee, Partners in Flight, and the Urban Biodiversity Information NODE. In addition to gaining information about monitoring programs at these conferences, the I & M team developed posters and oral presentations to promote the program and solicit responses to the planning process.

A wide variety of monitoring programs exist throughout the region. Many are localized, such as those implemented by volunteers (e.g. DC Audubon), and some are part of national efforts (e.g. USGS Breeding Bird Survey and the Amphibian Research and Monitoring Initiative). In addition, there are statewide ecosystem health monitoring efforts, as in the state of Maryland, and regional efforts, such as those conducted by EPA Mid-Atlantic Integrated Assessment or the US Forest Service's Forest Inventory Analysis.

In addition to interviews, the I & M staff conducted an extensive literature search to summarize data from inventory and monitoring efforts in the region. Over 3,000 articles and documents relating to the region's natural resources have been collected and are cited in the online NPS bibliographic database (NatureBib). Much of the data is being reviewed and will be added to the national online inventory database (NPSpecies). The literature will also provide background information on monitoring efforts and protocols.

3. Hold a monitoring workshop

    This document summarizes the results of the *National Park Service Monitoring Workshop: Planning for the future in the National Capital Network*, which took place 9-11 July, 2002, at the U.S. Fish and Wildlife Service's National Conservation Training Center in Shepherdstown, West Virginia. The workshop was designed to provide a forum to exchange technical ideas on what should be monitored in the National Capital Network and how the program could be implemented. It was also designed to foster partnerships among NPS divisions and with regional conservation groups and agencies to enhance and protect the region's most valuable natural resources.

    Over 250 people were invited and more than 100 participants attended the monitoring workshop. Nearly half represented the NCN parks, including park resource managers, rangers, assistant superintendents, superintendents, and regional natural resources and science staff. NPS scientists from Air Resource Division, Water Resource Division, Geology Resource Division, Natural Resource Information Division, and other National Parks also participated. Additional participants represented over 20 organizations and partnering agencies, including universities, The Nature Conservancy, NatureServe, USGS, EPA, Department of Defense, USDA Forest Service, and the Smithsonian Institute.

4. Write workshop report and have it reviewed

This document synthesizes the results of the monitoring workshop and will be circulated among participants and other interested parties for feedback.

5. Decide on priorities and implementation approaches

    Upon receiving feedback on the Monitoring Workshop Report, the NCN I & M staff and Science Advisory Committee will meet to discuss priorities among monitoring goals and objectives. Protocols must also be developed and evaluated for their effectiveness.

6. Draft a monitoring strategy

    Draft Chapters of the Monitoring Plan are scheduled for completion as follows:

    Phase I Report (due 1 October 2002) includes draft Chapters 1, 2 and 3, which focus on the region's important resources, planning process, and conceptual models as well as an executive summary.

    Phase II Report (due 1 April 2003) includes revisions of Chapters 1, 2 and 3 along with draft Chapter 4, which discusses vital signs selection.

    Phase III Report (due 1 April 2004) will include revisions of previous chapters, an executive summary, a data management plan with outlines of database structures, field data sheets, monitoring protocols, a discussion of how data will be analyzed, budgets, staffing needs, and partnerships.

7. Review and approval of monitoring plan

    All phases will be peer reviewed prior to final approval by the Board of Directors and NPS Natural Resource and Information Division. Funding for implementation has been allocated but is contingent upon final approval of the Monitoring Plan.

Planning Team

The NCN I & M staff includes a regional I & M Coordinator to oversee the planning process, a Monitoring Coordinator to develop the monitoring plan, a Biological Inventories Coordinator to manage the biological inventories through their completion, and a Data Manager to develop centralized databases for both inventory and monitoring projects. The program is supported by two biological technicians who conduct literature searches, data entry, web-page development, and are an integral component of the planning team. The I & M staff is augmented by the region's two hydrologists who are charged with developing the water-related components of the monitoring plan. I & M staff are administered along with regional Natural Resources and Science staff at the National Capital Region's Center for Urban Ecology.

Products

The program will synthesize information needed by resource managers to make management decisions. Both Inventory and Monitoring data will become available via the network's web page (http://www.nature.nps.gov/im/units/nw12/index.html) and online databases (e.g., NPSpecies, NatureBib, etc.) and shared through a variety of standardized comprehensive databases including GIS components. Annual reports and work plans will be in line with the national requirements.

Timeline and Next Steps

Next steps include prioritizing monitoring goals and objectives among those identified by each workgroup. Protocols must be also be identified or developed and tested. In addition, a complete strategy must be developed to implement the monitoring program, including field components, data management and analysis, and outreach to ensure integration into park management.

Products and expected dates of completion are as follows.

Activity	**Expected date of completion**
BOD Meetings	Fall '01, Spring '02, Fall 02, Spring '03, Fall '03, Spring '04
SAC Meetings	Fall '01, Winter '02, Spring '02, Summer '02,Fall '02 - Spring '04 as needed.
Monitoring Workshop	9-11 July '02
Workshop Report	Fall '02
Annual Workplan and Report	1 Oct. '02
Phase I Report	1 Oct. '02
Phase II Report	1 April '03
Annual Workplan and Report	1 Oct. '03
Phase III Report	1 April '04
Annual Workplan and Report	1 Oct. '04

Monitoring Workshop – Day 1

Purpose of Meeting

Continue the development of an integrated and comprehensive long-term monitoring plan for the NCN of the National Park Service that provides essential information needed to preserve and enhance the region's most important natural resources.

Expected Outcomes of the Workshop

As a result of the meeting, the I & M program will:

(1) create a network of stakeholders (including park divisions, educational institutions, and other agencies) united to preserve the most important resources in the NCN.

(2) review technical information developed by the Science Advisory Committee to lead to the development of a long-term monitoring plan of the region's most important resources.

> Specifically, we will:
>
> (a) identify major threats (stressors and their sources) and their ecological effects to each important natural resource within the NCN
> (b) identify ecological indicators to monitor important resources and their threats
> (c) develop priority monitoring objectives in line with monitoring goals guiding the National Park Service Inventory and Monitoring Program
> (d) identify protocols that could be used to monitor indicators
> (e) identify collaborative approaches to implement monitoring.

Powerpoint Presentations

All presentations are posted to the NCN I & M Website:
http://www.nature.nps.gov/im/units/nw12/monitoringworkshop.html

- Dr. Steve Fancy: The National Park Service Inventory and Monitoring Program – how is this program relevant to the parks?

- Dr. Ellen Gray: Overview - The National Capital Network I & M Program.

Breakout Sessions:

Topic 1. Managing the Parks.

Using sound science to support park operations. The Inventory and Monitoring Program is directed to provide relevant information to park managers. A presentation focused on the information that is being developed by the Inventory and Monitoring Program. A discussion followed exploring the utility of the information and how applied science and long-term monitoring can support park operations.

Purpose: Define how the NPS I & M Program can provide scientific information to the parks in a way that enhances park management.

Expected Outcomes:

1. Foster an understanding of I & M products
2. Identify park and regional information needs
3. Identify how to meet information needs

Presentation:

John Sinclair, NCN Biological Inventories Coordinator, discussed the type of information that is being developed by the NPS I & M Program. I & M database products were highlighted, including: 1. NPSpecies (inventory database), 2. Permit System (online research permit request form), 3. Natural Resource Profiles (natural resource information available for each park), 4. Database Template (monitoring database with GIS component), 5. Dataset Catalog and Metadata (metadata for datasets and GIS data respectively), 6. NatureBib (online park literature lists), and 7. Theme Manager (ArcView plug-in used to develop standard GIS maps and enhance ease of use).

Discussion focused on three questions:

1. What information can the I&M planning process provide to parks in order to best manage the resource?
2. What mechanisms exist or can be created to keep lines of communication open as the project continues to ensure that the resultant plan is relevant and useful to resource managers and other stakeholders in the parks?
3. What circumstances, events, etc. should be anticipated as potential challenges or roadblocks to this effort?

Group comments addressing the questions were captured under 3 categories: Information, Communication, and Challenges.

Information:

1. There should be a way of linking natural, cultural, and historical landscape information over time. It should be possible to cross-reference and coordinate with GIS.
2. There needs to be reliable and/or current species lists and an associated time frame.
3. There is a need for time series information and the use of consistent protocols over time.
4. When establishing monitoring / sampling sites, ensure that some historic sampling locations are included with new sampling locations.

5. When monitoring, a method of documenting the absence of a species over time is needed.
6. Need to demonstrate how the park is representative of the surrounding ecosystem.
7. Need more than a species list (what other biological data is associated with it?).
8. Need to identify threshold levels for a particular resource.
9. Expand the data beyond the boundary of the park to give an overall picture.
10. Need to provide the information in a manner usable at the chief level without going to natural resource staff.
11. Need to provide information in a manner to get Superintendents interested in the program.

Communication:

1. Need to have someone with knowledge of various communication skills in order to sell the program to upper level management.
2. Should have a mechanism to integrate the program with existing environmental education programs.

Challenges:

1. How to make natural resource management proactive. Be able to integrate the information gathered into long-term management plans.
2. External factors that cannot be controlled.
3. Natural systems are variable. Time required to get enough information to identify unnatural changes.
4. Ability to identify when new monitoring criteria are needed.
5. Funding to adequately cover the monitoring of resources in a manner that will provide adequate useful information to the parks.

Facilitator: Glyn Thomas, Avatar, Inc.

Topic 2. Monitoring Natural Resources through Partnerships.

A presentation highlighted the products being developed by the Inventory and Monitoring Program. A discussion explored the need to enhance existing or develop new partnerships among scientists, land managers, and the I & M Program to ensure that the region's most critical resources are being adequately monitored using rigorous protocols and can be protected.

Purpose: Identify ways that the NPS Inventory and Monitoring Program can facilitate partnerships between parks and the scientific community in a way that protects the region's natural resources.

Expected Outcomes:

1. Foster an understanding of I&M products
2. Examine existing partnerships
3. Identify park needs for partnerships relating to long-term monitoring
4. Identify partnership opportunities
5. Identify I&M role to facilitate partnerships

Presentations:

Ellen Gray, NCR I&M program, highlighted the information management products being developed by the I&M program. There was a question about putting sensitive information and information to be published on the web in the Investigator's Annual Reports. Jennifer Lee, Resource Manager – Prince William Forest Park, and Diane Pavek, NCR Botanist explained that the researcher can request that certain parts of the data (sensitive or later to be published) be marked as sensitive so that they would not appear on the web.

Doug Curtis, NCR Hydrologist, presented an example of an existing partnership between NPS and the Maryland Biological Stream Survey (MBSS) program. NPS participated in MD DNR's established training program, will adopt their stream sampling manual with some additions, and will be able to compare data with the Maryland program.

David Russ, Mid-Atlantic representative for all USGS divisions, discussed activities of USGS relevant to NPS I&M. The USGS Eastern region has a focus area strategy of five science themes: sustainability, ecological health and integrity, safeguarding human health, assessing natural hazards and risks, and transferring scientific information. Criteria for a focus area include demonstrated programmatic priorities that require a strong future USGS presence, clear connection to multiple customers and coalitions, identified relationships with other federal and state partners within a geographic area, and long-term USGS commitment to the area. Current focus areas include the Appalachians and Mid-Atlantic region. USGS will be preparing a plan for the Mid-Atlantic region this fall. Relevant projects: 1) Identification and testing of variables for monitoring estuarine nutrient enrichment in North Atlantic parks (Northeastern Coastal and Barrier Network plus coastal units of Northeastern Temperate Network), and 2) Urban dynamics with the Mid-Atlantic Federal Partners for the Environment.

Discussion focused on three questions:

1. What partnerships may be needed to monitor natural resources in the region?
2. How can the NPS I&M planning process assist in the development of these partnerships?
3. What circumstances or events should be anticipated as potential challenges or roadblocks to this effort?

The group's discussion relative to the three questions posed above is summarized in Table 1 below.

Table 1. Summary of discussion during breakout session: Topic 2. Monitoring Natural Resources through Partnerships.

Partnerships	**I&M role**	**Challenges**
Forest Service (Chip Scott): Contextual data on forests (also EPA web-based report, f*orest health in the Mid-Atlantic region*); fragmentation maps using satellite imagery for the NE region; Forest Inventory Analysis (FIA); partner for intensification (web)	Borrow FIA sites and site selection protocols – take advantage of Forest Service's process for selecting plots	FIA samples in proportion to occurrence, not targeted sampling. May need to consider targeted areas in site selection process.
Virginia Tech Natural Resources Program (David Trauger): urban biodiversity, urban watershed, and urban forestry research; graduate students are looking for projects; involvement in development of protocols; concerned about peer review; can also draw on resources of the Blacksburg campus	Include VA Tech at the table for protocol development and peer review	
Utilize students at university, high school, and younger levels: - Bridging the Watershed Program (NPS/Alice Ferguson Foundation with DC area schools) - Chesapeake Watershed CESU - Geoscientists in the Parks (GRD, Judy Genice, Denver)	Involve park staff in standardized monitoring with graduate students	Safety concerns of using young people in monitoring programs; data integrity of information gathered by young people; sustainability of volunteer labor/knowledge base; graduate students will be less interested in ongoing data collection than original research
Use existing databases (i.e. EPA – air quality, climate change) for regionally driven stressors (George Taylor)	Use existing databases (i.e. EPA – air quality, climate change) for regionally driven stressors (George Taylor)	

Partnerships	I&M role	Challenges
Museum collections as a source of legacy data (border areas) - Museum of Natural History - George Mason University - Others		Museums are sensitive to ownership issues of artifacts, specimens, and objects and may be reluctant to telling NPS that they have specimens collected on park lands
National Biological Information Infrastructure: overall coordination of vital signs information (David Trauger)		
EPA: National report card on condition of environment (looking for core indicators of ecosystem health at a national level). Preliminary report due in November 02; National Land Cover Data Set.	Can work with other networks to create consistency in indicators and protocols across the country	Staying consistent with monitoring protocols over time
Society for Cultural Geography (Sheryl Beachs)		
Maryland state management agencies have low turnover and wealth of relevant data - Fisheries Service - Wildlife - Maryland Forest Service - Natural Heritage (train volunteer monitors) - Maryland Gap Analysis	Establish point of contact for state agencies	
Virginia state management agencies (Jeff Waldon) have contextual data for parks - Forestry - Fish/Wildlife - Virginia Gap Analysis project (web/cd) - VA Fish/Wildlife Information Service (VA game and inland fisheries website)	Establish point of contact for state agencies	
National Science Foundation – Urban Ecology and Biodiversity program (Baltimore LTER)	Research protocols NSF has developed	
Information Management Program – SHEN (Alan Williams, at VA tech for SHEN)		
USGS NAWQA (Holly Wyers)– two urban pilots for water monitoring (Delaware River, Philadelphia and Mobile) – protocols will be available; may be able to partner on special projects (standard programs possibly) and potential to merge data collection	The district office in Dover started a new project examining mercury concentrations in fish tissue. Because the NAWQA biologist knew of ROCR's interest in this area, they were able to move the sampling site to ROCR.	
Remote sensing projects (George		

Partnerships	I&M role	Challenges
Taylor): NOAA; NASA, Steve Prince, Mayland; Kafatos, George Mason; programs eager to apply tools to the landscape		
Data available at county level regarding development outside parks (Pete Chirico, USGS)		
USGS: relationship between bird populations and county development efforts (Dianna Dawson)		
Virginia Tech – available to assist in vegetation mapping		
	Will need to determine how to coordinate timing for data collection based on phenology and/or organizational constraints; I&M can request other organizations to adopt the same protocols (leadership role in monitoring standards and validity of protocols); advocacy for comparability of methods (other than conformity)	Phenology: challenges of timing for monitoring various species; timing sampling based on biology/life history or when other programs do it for comparability, when seasonal technicians are available, etc.
	Serve as a clearinghouse for who is doing what (Pam Underhill)	How will overall coordination be done? Assessing vital signs on a landscape scale
		Changing technology and changing understanding of what should be monitored will be an ongoing challenge
	Develop strategic plan for I&M program to obtain future/on-going funding	Limited funding; user demands of data may increase the costs over the years
USGS partnership potential to identify accuracy and precision of statistics generated		

The group identified next steps for the I&M program relative to partnerships:

- Continue to cast the net to involve other stakeholders in this process. Dave Trauger mentioned that there are key people involved in monitoring in the region that were not present. He will send a list to Ellen Gray.
- Create coordinating mechanisms to continually engage with partners
- Evaluate the role that NPS I&M is and will play
- Identify the scope of the effort (BOD/SAC)
- Establish peer review process all along the way

Facilitator: Sue Thomas, Avatar, Inc.

Topic 3. Interpreting the Region's Natural Resources.

The National Park Service has a long-standing tradition of interpreting the parks' and the region's natural resources. A presentation highlighted the information being developed by the Inventory and Monitoring program. A discussion focused on how this information could be used to support interpretation and education programs to enhance the public's understanding of the region's natural resources. Additional information needs were explored.

Purpose: Define how the NPS I&M Program can link science and interpretation / education in a way that enhances public understanding of natural resources.

Expected Outcomes:

1. Foster an understanding of I & M products
2. Identify interpretation/education needs
3. Link science resources and interpretation needs

Presentation:

Christina Wright, NCN Data Manager, highlighted the information being developed by the Inventory and Monitoring program. Discussion focused on how this information could be used to support interpretation and education programs to enhance the public's understanding of the region's natural resources, as well as additional public information needs.

Discussion focused on three questions:

1. What natural resource information is requested?
2. How might I & M products be used to answer these questions?
3. What additional information needs do you have? How can the I & M program meet these needs?

Before addressing the three discussion questions, the question of whether or not natural resources should be incorporated into interpretation at cultural resource oriented parks was broached. Does discussion of these parks' natural resources support the key points of the park? The group felt that all interpretation programs should include both natural and cultural resource elements because the ecological setting or ecoregion of the park influenced why battles took place, where houses were built, and/or which crops were raised.

1) What natural resource information is requested?

1. Interpretators need information regarding current and ongoing studies within the park, including when, what, and the results of the I & M studies. The research permit site has some of this information, but there needs to be better communication between resource managers and interpretation staff. Visitors observe these activities and ask about them.

2. An explanation of park management decisions and maintenance activities - basically anything that is visible and ongoing in the park. Visitors observe these activities and ask about them.
3. What did the park look like in the past? What are the population trends and dynamics?
4. General historical information about the park.
5. Pollution related issues: air quality, trash, water quality etc.
6. What impacts do visitors (and their pets) have on park resources?
7. Are the water bodies in the park safe for human use? What about trash and pollution?
8. "Park animals" that move from the park to non-park property. What are you going to do about them?
9. Rabies, lyme disease, west nile virus and their monitoring. What is happening with these issues?
10. Why are the trees dying? Why do sycamores peel? Etc.
11. What is the latest news regarding hot media topics (outbreaks and concerns)? Interpretation staff is not adequately supplied with this information.

2) How might I & M products be used to answer these questions?

1. Having two versions of the NCN I & M annual report - one technical and one a summary that would provide information about the presence/absence of species (particularly those of interest to the public), abundance data, mapping products, and an explanation of the data. Other useful information would be photos and maps and a description of trends that other parks may want to investigate.
2. The annual report might also allow the sharing of information between the parks, such as trends, invasive species update, sightings of rare or unusual species, declining populations etc.
3. The I & M long-term monitoring plan should include a provision for funding and monitoring of emergent issues - such as invasive species, disease or pest species etc. It is important that the I & M program remain dynamic, be continually updated so that the program remains current.
4. Trends - making trend data available to interpretation staff would be very helpful in answering questions from the public.
5. Having a publicly available website that includes information on monitoring in the region, with supporting information that includes protocols, field forms, and database information. This site might also have links to current and historic monitoring efforts in the region, reports, photos and maps to keep the public and NPS staff informed.

3) What additional information needs do you have? How can the I & M program meet these needs?

1. To provide interpretation staff (as well as natural resource managers) with more information about NPS and I & M databases. This information would also address where to direct questions and concerns regarding those databases.

2. Help develop natural resource interpretive programming, especially at parks traditionally focused on cultural resources.
3. Facilitate better communication between natural resource management staff and interpretation - particularly relating to current research in the parks. Interpretation must answer questions from the public regarding activities they observe at the park - which is difficult if the interpretive staff isn't made aware of projects going on at the park.
4. Develop a master listing of key contacts for databases and I & M programs at multiple levels: internally (at the park), regionally, and nationally.
5. Provide a database of available funding sources for park monitoring or research projects, including deadlines and where to look for submission requirements.
6. Provide a database of locally available professionals/experts by subject area.
7. Provide a means to link in to external (non-NPS) data that may be of interest to park staff due to proximity, similarity of situation, etc. Facilitate the sharing of data between different agencies.
8. Provide additional/supporting information about species (ecology, threats, natural history) found in parks as well as how to identify those species.
9. Where possible, provide species lists with maps and photos from different time periods for comparison of data.
10. Creation of NPS brochures for high profile topics (and the I & M effort in general) to keep the public aware of these programs in the park.
11. Immediate response to provide information on "hot media topics" such as West Nile Virus, snakehead, etc. that are of high interest to the public. These are generally related to disease/pest organisms and invasive species. Perhaps a website or listserv to address fast and up and coming issues in the region and in the park.
12. Set up a chat room or listserv where park service staff can discuss and share information as well as having a place for visitors to report sightings.
13. Information about visitor use, visitor use impacts, and general safety information.

Other Issues:

1. Interpretation often uses signs as a method to educate the public. What is too few / too many?
2. How would park personnel find out information regarding human health related issues?
3. Does the I & M program have any requirements about output to be given to other agencies or organizations?

Additional Questions from the I & M information presentation:

1. What taxonomic groups are included in NPSpecies?
Mammals, Birds, Fish, Reptiles, Amphibians, Spider/Scorpion, Crab/Lobster/Shrimp, Insect, Slug/Snail, Other Non-vertebrate, Other Animal, Vascular Plant, Non-vascular Plant, Other Plant, Fungi, Protista, Monera.
2. Is it possible to flag data in NPSpecies to indicate that it has been verified or QA/QC checked?   *Not at this point in time.*

3. Programming format?
NPSpecies is in Oracle for the online version and in MS Access for the desktop version.
4. Relationship of TSN# and ITIS?
TSN stands for Taxonomic Serial Number and is a species-specific number that is assigned within the IT IS (Integrated Taxonomic Information System) database - thus no two species have the same number.
5. How complete is NRProfiles? Are there gaps for some parks? Who fills it in?
NRProfiles is a service-wide effort to showcase natural resource information through a link off each park's internet home page on Park Net. For the National Capital Region parks, there are currently 3 parks that have gone live (Chesapeake and Ohio Canal National Historic Park, Manassas National Battlefield Park, and National Capital Parks - East). The NRProfile for each park is only as complete as the parks decide to make it, as it is the park staff that creates the profile. The minimum requirements to go live are the completion of the main NRProfile page (containing a general overview of park resources), and the main page of each resource grouping (e.g. Plants, Animals, etc.). Photos are not required. The national deadline for completing the NRProfiles is September 2002.
6. Public accessibility?
NPSpecies is not currently accessible to the public and there is no target date for allowing public access at this point in time.
7. Not all data are correct. Not all data are in there. Who fixes it? How quality controlled is it? Is it possible to sort by date or person entering it?
Park staff and the regional I & M staff (Chris Wright and Sybil Hood) have been entering data into NPSpecies from current studies as well as from legacy data. At this point most, but not all, park data have been entered into the database. When using the online database, there is always a record of who entered each data and who modified the data (if future editing occurs). The data in NPSpecies needs to go through a rigorous quality control effort - both to verify data entry, as well as for the species information itself.
8. Availability of GIS and training? Funding for this?
There is some GIS training available through the regional GIS support office (main contact is Tammy Stidham). There are also courses offered by ESRI (www.esri.com) and other sources. Unsure about the availability of funding for GIS training.
9. NPSpecies records name and date, what about location?
NPSpecies accepts GPS coordinates as UTM coordinates or Latitude and Longitude pairs. Other information, such as elevation and general location descriptions may also be included with NPSpecies data.
10. It was suggested by participants that the databases should not be mentioned to the public because the data are not currently available to them, the data cannot be guaranteed current, and there is a need for stabilization of protocols for dealing with the data.

Facilitators: Marian Norris, NPS – National Capital Region; Christina Wright, NPS - I & M National Capital Network.

Monitoring Workshop – Days 2 & 3

Powerpoint Presentations

All presentations are posted to the NCN I & M Website:
http://www.nature.nps.gov/im/units/nw12/monitoringworkshop.html

- Mikaila Milton: Introduction to the Science Advisory Committee and Today's Outcomes.

- Dr. Steve Fancy: What are Vital Sign Indicators?

- Wendy Cass: Setting Monitoring Goals and Objectives.

Breakout Sessions Overview

The workshop participants broke out and joined the eight existing workgroups that are focusing on key resources in the National Capital Network: Air, Geology, Invertebrates, Landscapes, RTE Species and Communities, Vegetation Communities, Wildlife, and Water. Each workgroup was led by a professional facilitator or an I & M staff member.

The purpose and expected outcome for each workgroup was stated as (except where noted):

Purpose

Continue the development of an integrated and comprehensive long-term monitoring plan for the National Capital Network of the National Park Service that provides essential information needed to preserve and enhance the region's most important natural resources.

Expected Outcomes

Review technical information developed by the Science Advisory Committee to lead to the development of a long-term monitoring plan of the region's most important resources.

Specifically, we will:

(a) Review conceptual models, including resource components, stresses, sources, ecological effects, and vital signs. Identify major threats (stressors and their sources) and their ecological effects to each important natural resource within the National Capital Region
(b) Identify ecological indicators (Vital Signs) to monitor important resources and their threats

(c) Prioritize most significant threats or vital signs using the prioritization table
(d) Develop monitoring goals and objectives for Priority Vital Signs in line with monitoring goals guiding the National Park Service Inventory and Monitoring Program
(e) Identify protocols that could be used to monitor indicators to meet monitoring goals and objectives
(f) Identify collaborative approaches to implement monitoring.

Conceptual Models: In order to meet expected outcome (a), the workgroups reviewed and modified existing conceptual models developed by the SAC. The initial models included all ideas generated by brainstorming. Vital signs were identified through this process in order to meet expected outcome (b).

Prioritization Matrix: Threats were initially prioritized by the SAC using loosely defined criteria ranging from High to Low. Unless otherwise noted, workgroups utilized a Prioritization Matrix to refine priority threats to resource components (outcome (c)). Each participant filled out a copy of the matrix independently. The sheets were turned in anonymously and the facilitator then averaged all the scores to generate a total score. The highest scores were interpreted as having the most significant threats. See Appendix C for a copy of the Prioritization Matrix and criteria definitions.

Goals and Objectives: Each workgroup wrote broadly defined goals and more specific objectives for each high priority threat (outcome (d)). The workgroups decided subjectively what would be the cut off for a high priority threat. Protocols were discussed and identified as time allowed to meet expected outcome (e).

Networking Opportunities and Collaborative Approaches: Days 2 and 3 of the workshop included unique opportunities to mingle, discuss conceptual models, and develop partnerships to meet expected outcome (f).

See Appendix C for handouts presented to participants, including the original conceptual models, the Prioritization Matrix, and other background information about the NCN.

Summaries from each session are presented below.

A. Air Workgroup

The air workgroup revised the original conceptual model developed by the Science Advisory Committee (Table 2). The workgroup reviewed which stressors actually had an effect on each resource and identified possible vital signs. Attributes that are intrinsically important to the ecological health of the Mid-Atlantic region are presented within the model. Most attributes discussed are physical components (i.e. visibility, particulates, aerosols, and precipitation), whereas others can be viewed as chemical (i.e. nitrogen, sulfur, and ozone) or biological (i.e. vegetation).

Table 2. Conceptual model of air resources in the NCN.

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource
I. Physical – presence of solids and aerosols in the atmosphere	a. wet/dry acidic deposition, b. ozone	Natural a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic a. Stationary (smokestack) utilities and industries, b. Mobile (planes, trains, and automobiles), c. Area (i.e. rock quarries)	a. Biodiversity (terrestrial and aquatic), b. Material and monument degradation, c. Health (increased biogenic emissions such as ozone precursors), d. Hydrologic, e. Soils, f. Increased energy use (pollutants)	low to medium
IA. Visibility – how far, how well you can see – regional haze	Particulates, aerosols	Natural a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic a. Stationary (smokestack) utilities and industries, b. Mobile (planes, trains, and automobiles), c. Area - small sources such as dry cleaners and rock quarries	Human perception, health of terrestrial living beings. Monitor monuments using photographic record of condition.	medium, due to severity of numbers of people here

(split table so row won't be split over 2 pages)

IB. Climate – precipitation, temperature,humidity	UVB, Urban heat island	Natural a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic a. Stationary (smokestack) utilities and industries, b. Mobile (planes, trains, and automobiles), c. Area (i.e. rock quarries)	weather changes - rainfall shadow	low
II. Chemical – elements and compounds that interact with air and lead to effects	a. Nitrogen, b. Sulfur, c. Metals (i.e. mercury), d. Ozone, e. PM(10) & PM(2.5), f. Greenhouse gasses, g. Hydrogen ion deposition, h. Air toxics	Natural a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic a. Stationary (smokestack) utilities and industries, b. Mobile (planes, trains, and automobiles), c. Area (i.e. rock quarries)	a. Biodiversity (terrestrial and aquatic), b. Terrestrial and aquatic eutrophication, c. Terrestrial and aquatic acidification, d. Toxicity affects-bioaccumulation, e. Material and monument degradation, f. Vegetation impacts, g. Climate change, h. Geographical shifts, i. Hydrology, j. Pest populations, k. Human health	ranges from high to low - intermittent, and depends on chemical

Priority Threats (all of which are products of urbanization)

For threat prioritization, the stressors were listed on the Prioritization Matrix (Appendix C) and assigned values. Each workgroup participant filled out a copy of the matrix and the facilitator totaled the scores for each parameter and then totaled for each stressor.

Top ten priority threats include:

1. Ozone (existing monitoring)
2. Particulates – Aerosols (existing monitoring / need digital camera)
3. Acid deposition (existing monitoring)
4. Total N deposition (need gaseous monitoring)
5. Urban heat island
6. Inorganic air toxics

7. Organic air toxics
8. UVB
9. Greenhouse gases
10. Sulfur deposition

Vital Signs

Potential vital signs were discussed by the workgroup. Monitoring visible injury to plants is controversial, but the U.S. Forest Service currently does this type of monitoring, and the NPS Air Resources Division is advocating monitoring foliar injury. The EPA is requiring states to monitor for toxics, but is not providing funding for these activities. Some regions and states including Baltimore, Washington D.C., Maryland, and Virginia are monitoring toxics including: heavy metals, volatile organic compounds (VOCs), and pesticides in gas phase. Air pollutants may also affect water quality. Monitoring should include tissue sampling of fish, predatory birds, and carnivorous animals. Analysis should be done for endocrine disruptor signals, dioxin, mercury, cadmium, lead, hexaphene, and benzene. Greenhouse gases are already monitored by states.

Goals and Objectives

Goals and objectives were developed for the top ten priority threats and are presented in Table 3.

Table 3. Monitoring goals and objectives for air resources.

Threat	Vital Sign	Monitoring Goals	Monitoring Objectives
Ozone	Monitoring (ambient) vegetation	Monitor ambient ozone concentrations and trends that affect human health and terrestrial ecosystems	Communicate risk of ozone to human health for employees and the public and assess impacts to terrestrial ecosystems
Particulates / aerosols	Ambient monitoring (digital camera) of visibility	Monitor particulates/aerosols for visibility impairments	Interpret the value of visibility
Acid deposition	Ambient monitoring	Monitor hydrogen ion concentration in deposition	Assess the impact of hydrogen in deposition on terrestrial and aquatic ecosystems
Total nitrogen deposition	Ambient monitoring	Monitor total nitrogen concentration in deposition	Assess the impact of total nitrogen deposition on terrestrial and aquatic ecosystems
Urban heat island effect	Temperature, precipitation	Monitor urban and regional temperature and precipitation	Assess the urban heat island impacts on terrestrial and aquatic ecosystems

Threat	Vital Sign	Monitoring Goals	Monitoring Objectives
Inorganic air toxics	Ambient air	Monitor deposition of inorganic air toxics	Coordinate the assessment of inorganic air toxics impacts on terrestrial and aquatic ecosystems
Organic air toxics	Ambient air	Monitor deposition of organic air toxics	Coordinate the assessment of organic air toxics impacts on terrestrial and aquatic ecosystems
UVB radiation	UVB-instrumentation, amphibians, genomic tech	Monitor UVB radiation levels in the region	Coordinate the assessment of UVB radiation impacts on terrestrial (vegetation) and aquatic (amphibians) ecosystems
Greenhouse gases	Ambient air	Monitor ambient levels of greenhouse gases in the region	Assess the impact of greenhouse gases on terrestrial and aquatic ecosystems
Sulfur deposition	Ambient air	Monitor sulfur concentration in deposition	Assess the impact of sulfur deposition on terrestrial and aquatic ecosystems

Protocols

The workgroup discussed protocols. Discussions brought out several key points:

1. There is already atmospheric monitoring occurring in NCN for ozone, particulates, and rainfall. Wherever monitoring is occurring in the region, I & M can use it as long as the monitoring follows national protocols.

2. Urban heat island: weather station information is important (temperature). CHOH is a good place to study urban heat island effects because it is a long, narrow park.

3. Air toxics – air, water, wildlife, vegetation, and geology workgroups need to coordinate. Coordinate monitoring of deposition of inorganic air toxics with water, wildlife, and geology workgroups to assess impacts of atmospherically-derived pollutants on terrestrial and aquatic ecosystems. Cooperating basis: Air workgroup will cover issues until it hits the ground, then the other workgroups will need to take that information into their area of expertise.

4. Greenhouse gases: much previous monitoring and effects data exists that can prove useful for assessments in NCN.

5. Regarding goals: there are national air standards. Reducing air pollution, at least outside of park boundaries, is beyond our control (inside our boundaries, parks should be practicing pollution prevention, etc.)

6. The general goal in the air workgroup is to detect changes in concentration and to make connections with other resources to carry the impacts to the ultimate vital signs.

Facilitator: Doug Curtis, NPS – NCR.

Participants: Tonnie Maniero, George Taylor, and Julie Thomas.

B. Geology Workgroup

Purpose: Continue the development of vital signs indicators for geologic resources in the National Capital Region of the National Park Service to provide essential information needed to preserve and enhance the region’s most important geologic resources.

Outcomes:

1) Complete the geology table from previous meetings, allowing time to clarify items already in the table and identify additional information gaps

2) Prioritize items in the geology table for future monitoring efforts

3) Develop monitoring objectives for high priority threats in the geology table.

4) Develop a list of potential protocols that would meet the above monitoring objectives from the geology table.

This breakout session began by reviewing the conceptual model describing the geologic resources developed by the geology workgroup of the SAC including (1) resource components, (2) stressors to those resources, (3) sources of stressors, (4) ecological effects, and (5) potential vital signs monitoring indicators. Terminology was clarified, existing information was edited, and new information was added. The results of this discussion are captured in Table 4 below.

One point that was not captured in Table 4 (but which should be noted) is that the geology workgroup examined soil from an agricultural perspective, rather than from an engineering perspective. In addition, several people in the group commented that geology is an integrative, long-term perspective for monitoring, although there are both short- and long-term indicators that may be used to examine threats to the geological resources in the NCN.

Other topics of discussion during the morning session were urban soils and "engineered or created landscapes". Urban soils are generally horticultural in context, some of which may be "engineered" but, by far, most urban soils are not. Urban soils tend to be non-agricultural or non-forest situations where man has, to one degree or another, manipulated the landscape such that the natural soil regime no longer exists. In most cases, soil structure has been lost or redeveloped. In many cases, urban soils were composed from subsurface soils and, therefore, nothing resembling an "A" horizon exists. Urban soils are often compacted, resulting in high bulk densities, and, as a result, have reduced oxygen content (e.g. trails, campsites, etc.). In addition, these soils are poorly drained, low in organic matter, retain little moisture, may be disconnected from the water table or capillary water, could be contaminated or have considerable "artifacts" (ash, glass, etc.), and are often depauperate in microfauna (bacteria, fungi) and macrofauna such as worms (even if most worms are non-native). Thus, many of the highly important landscape areas of National Capital Region, including the National Mall, battlefield cemeteries, visitor centers, picnic areas, trails, tow paths, etc., are places where manipulated soils need to be understood from their creation, through use and then management.

In addition, created landscapes were identified as one of the more unique, geological components of the National Capital Network (and especially, Washington DC), and for which the group felt that very little information currently was available. On one hand, these changed environments could lead to increased diversity - due to the potentially more-complex mosaic of soils and resulting vegetation communities. On the other hand, these landscapes are commonly affected by human manipulation, horticultural and agricultural practices, and urban landscaping efforts, all of which tend to lower biodiversity and lead to an increased occurrence of exotic species.

Several potential research topics were also discussed: historical records of floods, sedimentation, and land use in the region. Historical records of floods should be relatively easy to find for the National Capital Region. For example, Metro records and historical documents may provide an indication of historic structures affected by flooding on a sequential basis. In addition, Jim Patterson (NPS - retired) may have a lot of background information on NCR parks. Sediment coring may also be used to provide a historical perspective on sediment "cycling" throughout the history of this region. The use of aerial photos, as available, may provide the necessary data to examine land use change over time, changes in stream morphology over time, and shoreline change over time. Finally, through the use of newer technologies such as LIDAR and GPS, it is possible to examine changes in topography and geomorphology, at a fine scale, which is especially important in the Piedmont and Coastal Plain areas of the National Capital Region that have little or no topographic relief (e.g. Dyke Marsh).

In the afternoon session, the workgroup focused upon ways to condense the list of 30 threats to geological resources into a more manageable size (Table 5). This proved to be a difficult task due to the varied nature of some of the components in Table 4. The first two categories, (1) nutrients and contaminants and (2) erosion and sedimentation, were natural groupings of many of the entries in Table 4. The remaining components of Table 4 were more difficult to categorize because they did not fit nicely into a single group heading. However, the workgroup was finally able to group the components into the following subject headings: nutrient and contaminant cycling, sediment cycling, engineered lands and urban soils, shoreline change, geo-hazards, human influences within the park boundary, and human influences outside the park boundary. The group next began to prioritize these subject areas, but decided that some of these categories were too contrived, or overlapped too much, to be separated out in this way.

The final geology working group session was held on Thursday morning. The group decided to continue through the prioritization process by beginning with the categories that they were satisfied with - nutrient and contaminant cycling, and sediment cycling. For these two groupings, the group suggested established protocols for monitoring, wrote monitoring goals and objectives and identified potential collaborators. Once this analysis was completed for nutrient/contaminant and sediment cycling, the discussion continued for engineered lands and urban soils, shoreline change and geo-hazards. The categories of human influences within the park boundary and human influences outside the park boundary were decided to be too broad and thus were eliminated from Table 4. Categories were then ranked by considering the significance of the threat to the parks in the NCN, which included the following factors: amount of area affected by the threat, intensity of the threat to the resource, urgency of the threat to the resource, monitoring feasibility, and cost of monitoring. By the end of the morning session, the group had decided upon the following categories, in priority order: nutrient and contaminant cycling, sedimentation and erosion, lack of understanding of engineered lands, shoreline change and geo-hazards. The workgroup then went back through Table 4 to assign all 30 elements to one (or more) of these specific groupings.

In addition to the work above, the workgroup noted information needs and studies of interest throughout the discussion. These are summarized below.

Information Needs:

A more recent and complete soils map for the region is needed.

Inventory information regarding land changes and the creation of lands for baseline data as well as how these lands change towards equilibrium is needed.

Are locations of air quality monitoring stations that also capture atmospheric deposition known? They need to be checked at the National Atmospheric Deposition Program (http://nadp.sws.uiuc.edu) or discussed with the air workgroup.

What about non-point source pollution monitoring in the region?

Is anyone considering the effects of acid rain on monuments in the region? *There was, at one time, a long-term monitoring project regarding this process (in DC)?*

Has anyone examined the flood and floodplain history of this area?

Previous studies of interest in NCR:

There were studies at 4-Mile Run beginning in the 1950's (pre-urbanization) to look at or capture the effects of urbanization.

Jeff Houser (Oak Ridge) has looked at the effects of sedimentation on streams and stream biota.

Table 4. Revised conceptual model for geological resources in the NCN.

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Soil	Pesticide loading	Agricultural, residential, and commercial use	Accumulation of pesticides that adhere to soil particles, causing changes to or the elimination of non-target soil fauna populations	High	1	Test soils and sediment for suite of pesticides commonly used in local area	Lithogeochemical studies (USGS), mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA
Soil/Bedrock	Nutrient loading	Agricultural, residential and commercial use	Acidification of the soil, reduction of soil organic matter, change in soil fertility status	High	1	Soil pH, soil N and P status, soil organic matter levels	Lithogeochemical studies (USGS), mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA
Soil/Bedrock	Change in pH, loss of buffering capacity	Acid rain, atmospheric deposition	Change in vegetation types, mycorrhiza and other soil flora, fauna	Unknown	1	Soil pH, acid neutralizing capacity (ANC)	Lithogeochemical studies (USGS), mass balance or input/output approach. Mass flow/hydrologic modeling.	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA
Soil	Temperature Change	Climate change	Changes in soil micro-climate	Unknown, locally high		Soil temperature/ moisture regime, changes in soil flora, fauna and mycorrhiza suite	Soil temperature and moisture monitoring. Soil organism analysis.		

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Soil/Surficial Factors	Clearing of land	Soil surface exposure, development, agriculture, zoning laws (local and county governments)	Loss of soil surface cover, increased soil surface and groundwater temperatures	High	2 and 3	Soil and groundwater temperature/ moisture regime. Change in vegetation community. Land use change.	Measurement of soil surface and groundwater temperature, monitoring of bare soils in region. Land use change analysis, vegetation community analysis.	Use survey and analysis methods to evaulate changes in topography, sediment loading and water flow rates.	Rebecca Beavers (NPS - GRD), Wayne Newell, Nancy Simon, Pete Chirico (USGS - Reston), EPA - Office of Water and ORD, USGS - NAWQA, Loren Setlaw (?), Doug Curtis (NPS - CUE), Don Weeks (NPS - Denver)
Soil	Erosion	Development, land clearing, increasing impervious surface	Increased siltation, reduced productivity/health/abundance of soil, plants, and aquatic organisms	High	2 and 4	Sediment loading, increased sedimentation and changes in sedimentation patterns, land use change, change in topography, shoreline change, change in wetland extent and condition.	Shoreline change/Wetland extent - aerial photo analysis. Change in topography - LIDAR, GPS. Changes in sedimentation - bedload analysis, storm water event sampling, total suspended solids, light penetration in water column. Condition of wetland - changes in wetland plant species, multiband aerial photography.	Use survey and analysis methods to evaulate changes in topography, sediment loading and water flow rates.	Rebecca Beavers (NPS - GRD), Wayne Newell, Nancy Simon, Pete Chirico (USGS - Reston), EPA - Office of Water and ORD, USGS - NAWQA, Loren Setlaw (?), Doug Curtis (NPS - CUE), Don Weeks (NPS - Denver)

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Soil/Surficial Factors	Erosion	Development	Change in "normal" sedimentation sequence and composition	Unknown, low	2 and 4	Increased deposition, change in scouring and deposition patterns, change in hydrologic flow regimes.	See above protocols. Also, analysis of sediment cores, including an analysis of historical sediment records.	Use survey and analysis methods to evaulate changes in topography, sediment loading and water flow rates.	Rebecca Beavers (NPS - GRD), Wayne Newell, Nancy Simon, Pete Chirico (USGS - Reston), EPA - Office of Water and ORD, USGS - NAWQA, Loren Setlaw (?), Doug Curtis (NPS - CUE), Don Weeks (NPS - Denver)
Soil	Change in vegetation/exotics	Development, nursery use of exotics	Change in soil organic matter composition, changes in soil flora and fauna, pH, nitrification rates	Unknown		Exotic species monitoring and control measures, soil chemistry, soil organic matter levels, soil pH, soil nitrification rates			
Soil, creation of new soils	Fill dirt: complete changes in soil physical and chemical composition resulting from filling in land areas with soil from another location (esp. DC)	Landfills, abandoned mines, land engineering	Changed, destroyed, or new soil profile, change in chemical composition of soil, introduction of toxics, introduction of impervious structures into soil profile, compaction. Resultant changes to biodiversity and vegetation communties. Changes to hydrologic cycle.	High - esp. urban	1 and 3	Assessment and description of soil profile, change in subsurface temperatures, change in land surface elevation profile, movement of physical debris from land, soil compaction, change in biodiversity of flora and fauna	Assessment and description of soil profile, surface and ground water monitoring (lithogeochemical studies), bulk density, porosity or other soil compaction measures.	To understand the functioning and components of engineered landscapes (components - landfills, engineered soils, etc.)	USDA - NRCS, Dick Hammerschlag (USGS - Patauxent), Wright Horton (USGS - Reston). Also see contacts for nutrient and sediment cycling.

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Soil	Compaction	Visitor Use	Changes in vegetation survival, changes in soil physical properties, creation of soil crusts (an impervious surface).	Urban, locally - high	1 and 3	Monitor soil compaction, bulk density, porosity, or other soil compaction measures. Formation of soil crusts.	Soil coring, bulk density, porosity or other soil compaction measures.	To understand the effects of visitor use upon the soil profile - includes social and offical trails.	
Soil	Impervious surfaces	Paving, walls, armored banks	Scouring, cutting/changing shoreline, flooding,	High	1 and 3	Increased velocity of storm water flow, land use change	Storm water event sampling, aerial photos to examine land use change.	To understand the effects of increasing impervious surfaces in the watershed upon hydrology.	Pat Bradley - EPA, USGS - NAWQA, EPA - Office of Water
Unique soils: calcareous and serpentine soils	Lack of information for these soils and soil in general	Lack of information for these soils and soil in general	Potential for damage to unknown/unmapped resource	unknown	1	Soils inventory work necessary.	Complete, up-to-date, high resolution soil maps	N/A	Pete Biggam - NPS, USDA - NRCS
Groundwater	Consumption of groundwater in excess of replenishment	Human, agricultural, residential, commercial use and domestic animal use	Reduced groundwater quantity, and quality. Loss of springs and seeps, wetland loss, changed of soil saturation zones. Change in drinking water quality and quantity.	High	1 and 2	Changes in groundwater table, Changes or loss of springs and seeps, change in extent of wetlands, changes in soil moisture profile.	Survey of groundwater table and groundwater chemistry. Groundwater flow monitoring wells		
Groundwater	Introduction of toxics, acid drainage (natural and mining)	Landfills, abandoned mines, land engineering, bedrock.	Reduced groundwater quality	high	1	Change in groundwater quality, quantity, and temperature. Increased toxics in groundwater.	Groundwater monitoring wells in conjunction with lithogeochemical studies (USGS), Mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Groundwater	Physical Failure	Landfills, abandoned mines, land engineering	Change in subsurface water flow patterns, change in subsurface temperatures, introduction of contaminants	High	5	Groundwater monitoring wells (flow and mapping), subsurface temperature changes	Aerial photo mapping of areas with potential physical failures. Park staff observations of potential geo-hazard sites. Expert analysis of geo-hazard sites on a periodic basis.	To use observation and assessment to provide an early warning of physical failure in order to protect the resource, visitors, and park infrastructure.	John Pallister, Bula Gori, Gerry Wieczoff - USGS
Groundwater	Water bypasses the soil profile	old/abandoned wells (farms)	Increased groundwater contamination with nutrients, pesticides and other chemicals	Unknown	1	Change in groundwater quality, increased toxics in groundwater.	Groundwater monitoring and monitoring of abandoned wells in conjunction with lithogeochemical studies (USGS), Mass balance or input/output approach. Abandoned wells need to be found and sealed to minimize contamination.	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA
Groundwater	Impervious Surfaces	Roads, buildings, infrastructure	Reduced water infiltration leading to reduced groundwater recharge, movement of water between watersheds	Medium	1 and 2	Map and monitor groundwater recharge areas, monitor groundwater table levels and chemistry, subsurface temperature monitoring.			

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Exposed rock	Cutting the toe of slopes, over-steepened slopes, dipslopes	Development, roads, structures, trails, flooding, vegetation death (hemlock etc.), logging	Reduced slope stability	Low	5	Slope failure, reduced slope stability, movement of materials downslope, erosion, gully formation	Aerial photo mapping of areas with potential physical failures. Park staff observations of potential geo-hazard sites. Expert analysis of geo-hazard sites on a periodic basis. Monitoring for gulley formation or increasing erosion.	To use observation and assessment to provide an early warning of physical failure in order to protect the resource, visitors, and park infrastructure.	John Pallister, Bula Gori, Gerry Wieczoff - USGS. Also see personnel under erosion categories.
Karst	Toxics: pesticides, dumping, spills	Agriculture, septic systems, sewage, dumping, industry, spills	Rapid movement of contaminants to ground water, change in ground water chemistry and resulting in change in biology	High – locally	1	Subterranean invertebrates, ground water chemistry/ quality	Analysis of subterranean invertebrates. Lithogeochemical studies (USGS), Mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Smithsonian Institute Invertebrate specialists. Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Karst	Nutrient loading	Agriculture, septic systems, sewage, dumping, industry, spills	Rapid movement of nutrients to ground water resulting in change to ground water quality and change in biology	High – locally	1	Subterranean invertebrates, ground water nutrient content	Analysis of subterranean invertebrates. Lithogeochemical studies (USGS), Mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Smithsonian Institute Invertebrate specialists. Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA
Karst	Structural collapse, sinkholes	Inappropriate construction practices, dissolution in karst areas	Change in biology due to changes in air flow and temperature, volume and flow of water increased in areas dissolution of bedrock	High – locally	5	Change in sinkhole size, aerial photos to capture surface changes, subsurface temperature monitoring	Aerial photo mapping of areas with sinkholes. Park staff observations of potential geo-hazard sites. Expert analysis of geo-hazard sites on a periodic basis.	To use observation and assessment to provide an early warning of physical failure in order to protect the resource, visitors, and park infrastructure.	John Pallister, Bula Gori, Gerry Wieczoff - USGS
Surface water	Impervious surfaces	Infrastructure, development, residential and agricultural use, rip rap, armoring etc.	Increased storm water flow, increased erosion, changes in sedimentation, changes in stream morphology, increased exposure to nutrients/pesticides, change in hydrologic cycle effecting floodplains, and floodplain/riparian buffer capacity, change in base flow	High	1 and 2	Stream storm water flow, flood frequency, sedimentation load, stream morphology. Photo points. Storm event sampling, Mass flow/hydrologic modeling	Lithogeochemical studies (mass balance approach).Shoreline change/Wetland extent - aerial photo analysis. Change in topography - LIDAR, GPS. Changes in sedimentation - bedload analysis, storm water event sampling, total suspended solids, light	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem. Use survey and analysis methods to evaluate changes in topography, sediment loading and flow rates.	Rebecca Beavers (NPS - GRD), Owen Bricker, Nancy Simon, Wayne Newell, Pete Chirico, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA - Office of Water, USGS - NAWQA

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
							penetration in water column. Condition of wetland - changes in wetland plant species, multiband aerial photography.		
Surface water	Pesticide loading	Agricultural, residential, and commercial use	Reduced water quality, fishery health, and aquatic invertebrate communities and populations	High	1	Test for suite of pesticides commonly used in local area.	Lithogeochemical studies (USGS), Mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA
Surface water	Nutrient loading	Agricultural, residential and commercial use	Reduced water quality, fishery health, and aquatic invertebrate communities and populations. Algal blooms, eutrophication	High	1	Soil water and stream levels of N and P. High algal growth, low light penetration	Lithogeochemical studies (USGS), Mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Coastal areas	Impervious surfaces	rip rap, armoring, coastal walls, dredging	Changes in water flow rates, unnatural erosion and deposition, changes in natural shoreline, changes in sedimentation, wetland flooding, changes in wetland extent.	High – locally	1 and 2	Sedimentation coring (deep cores - research, shallow cores - monitoring), mapping of shoreline change, use of Pope's Creek as a reference area	Using aerial photos or survey methods to map shoreline and shoreline change over time.	Use mapping or survey methods to track changes in shoreline and depositional patterns, over time.	NOAA (?)
Lakes, ponds, seeps, vernal pools	Nutrient loading	Agriculture, residential lawn care, vegetation change	Eutrophication, change in fauna (esp. herps), effect upon T&E species	Unknown	1	Size/volume, chemistry, and temperature of surface water component	Lithogeochemical studies (USGS), Mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA
Lakes, ponds, seeps, vernal pools	Pesticide loading	Agriculture, residential, and commercial use	Addition of herbicides and pesticides to surface water, change in fauna, effect upon T&E species	Unknown	1	Pesticide, herbicide content of surface water component	Lithogeochemical studies (USGS), Mass balance or input/output approach	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	Owen Bricker, Nancy Simon, Wayne Newell, Wright Horton, David Russ (USGS - Reston), Mark Nellis (USGS - Denver), USDA, EPA, USGS - NAWQA

Resource Component	Stressor	Sources	Ecological Effects	Priority of Threat to Resource	Grouping used in priority table	Indicator/ Vital Sign	Protocol	Monitoring Goal	Potential contacts or collaborators
Riparian areas, Wetlands	Change in soil surface elevation and horizontal dimensions	Land engineering resulting in changes to deposition and erosion, dredging, dumping, creation of impoundments and dams	Disruption to the wetland/riparian ecosystems, change in storm water flow rates, vegetation change, wildlife change, change in stream bed characteristics	High	4	High resolution riparian/ wetland elevation monitoring, vegetation monitoring, sediment budget, changes in size of wetland area	Changes in wetland extent - aerial photo analysis. Change in topography - LIDAR, GPS. Changes in sedimentation - bedload analysis, storm water event sampling, total suspended solids, light penetration in water column. Condition of wetland - changes in wetland plant species, multiband aerial photography.	Use survey and analysis methods to evaulate changes in topography, sediment loading and water flow rates.	Rebecca Beavers (NPS - GRD), Wayne Newell, Nancy Simon, Pete Chirico (USGS - Reston), Richard Lowrance (USDA/ARS), EPA - Office of Water and ORD, USGS - NAWQA, Loren Setlaw (?), Doug Curtis (NPS - CUE), Don Weeks (NPS - Denver)

Table 5. Priority threats, vital signs, and monitoring goals and objectives for geological resources in the NCN.

Threats (in priority order)	Vital Sign	Monitoring Goal	Monitoring Objectives
Nutrient and chemical contamination	Changes in soil and ground water chemistry.	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	(1) Measuring nutrient inputs from sources pertinant to each park unit. (2) Measuring contaminant inputs from sources pertinant to each park unit. (3) Tie information from numbers 1 and 2 to the hydrologic cycle, flood history, flood effects, and flood impacts.
Erosion and sedimentation	Changes in topography, sediment loading and deposition, shoreline change, wetland extent and condition.	Use survey and analysis methods to evaluate changes in topography, sediment loading, and flow rates.	(1) Measure loss of soil, growth of gulleys, changes in streambanks…. (2) Track sedimentation history, effects, and impacts (including streams and ponds, hillslopes and gulleys).
Lack of understanding of urban soils and engineered lands	Compaction, runoff, chemical composition, soil profile and structure, biodiversity.	To understand the functioning and components of urban soils engineered landscapes and their effects upon resident biota. Components include: highly impacted soil (compaction in and around trails, visitor centers), landfills, engineered soil, etc.	(1) Measure changes to physical components of urban soils and engineered lands and correlate with changes in resident biota (and exotic species). (2) Measure contaminant outflow from landfills, abandoned mines, etc.
Shoreline change	Inundation of wetlands, erosion and sedimentation processes.	Use mapping or survey methods to track shoreline change and depositional patterns.	(1) Measure shoreline change using aerial photos, LIDAR and survey methodologies and correlate changes to development, when possible. (2) Use sediment coring and historical data to understand long-term flood histories.
Geo-hazard	Physical failure, rock falls, landslides, sinkhole collapse.	Use observation and assessment to provide an early warning of physical failure to protect the resource, visitors, and park infrastructure.	(1) Monitor areas of potential hazard due to unstable slopes, rockfalls, etc. (2) Monitor for changes in unstable engineered sites or areas that are geologically active (e.g. Potomac Gorge). (3) Document and monitor areas underlain by swelling clays.

Facilitator: Christina Wright, NPS – NCN I & M Program; and Dale Nisbet, NPS - HAFE

Participants: (contact information provided in Appendix B)

Joe Calzarette, Michelle Clements, Sid Covington, Dick Hammerschlag, Bob Higgins, Wright Horton, Lindsay McClelland, Wayne Newell, Scott Southworth, L. K. Thomas, and Ed Wenschhof.

C. Invertebrate Workgroup

Outcomes:

1. Identify importance of monitoring invertebrates
2. Identify feasible monitoring protocols
3. Identify information gaps
4. Identify collaborative approaches to monitoring

Discussion

Due to limited background information available for the invertebrates, the SAC invertebrate workgroup did not develop a conceptual model. The workgroup noted that a threat analysis was inappropriate given how little is known about invertebrate life histories and their status in the NCN parks. Invertebrate inventories have not been completed for any of the parks. Instead, this breakout session began by brainstorming broadly defined reasons for monitoring invertebrates and described how monitoring could be useful to the parks. The workgroup prioritized monitoring needs based on the amount of information that would be provided to resource managers about management objectives, including habitat restoration, exotic species management, conservation of rare or exemplary communities, and invertebrate biodiversity. Six monitoring projects were developed and the workgroup identified protocols that would also support a general inventory.

In order to address the outcomes stated above, the group discussed the following items.

a. Why is it important to monitor invertebrates?
b. What information will such monitoring provide to parks?
c. What are the methods used to monitor invertebrates?
d. What information must we have in order to implement monitoring (information gaps)?
e. What is the cost effectiveness and feasibility of each of these methods?
f. What other concerns must be addressed (next steps)?

The results of the discussion are summarized below.

1. Rare species (High Priority)

a. Rare species need to be preserved in the NPS.
b. The NPS will receive information needed to preserve its overall biodiversity, especially rare species.
c. Protocols will vary depending on which rare species are identified for monitoring.
d. Rare species are largely unknown because of very limited inventory work.
e. Monitoring rare species probably will be low cost.
f. Next step: Develop a list of known rare invertebrates. Also develop a list of possibly rare species in the region to supplement list developed by RTE workgroup. This list should be reviewed by State Heritage Programs, USDA, Smithsonian, and others. Responsible: Marcus Koenen will forward a list of RTE species meeting our criteria to participants. Participants can

suggest monitoring protocols. **Note:** During the Thursday afternoon poster session, it was recommended that Heritage ranking be adopted in addition to relying on subject matter experts.

2. Indicator of habitat (including water) quality (High Priority)

a. Indicators provide a way to evaluate multiple threats.
b. NPS will receive information on habitat quality by monitoring invertebrate species. Invertebrates can provide information about ecosystem change because of their sensitivity to changes and occupation of a wide variety of niches. In addition, invertebrates are visible and easy to collect.
c. Protocols will vary depending on which species are identified as rare ones.
d. Indicator species are largely unknown because of very limited inventory work.
e. Probably will be low cost.
f. Next step: The first invertebrates to monitor are those in rare communities. The invertebrate workgroup would like to review rare communities identified by the RTE workgroup in order to suggest appropriate invertebrate indicators if they are known. Potential indicators that would meet the criteria identified in Steve Fancy's talk "What are Vital Signs" were discussed. Butterflies and aquatic insects, including dragonflies, mayflies, and stoneflies, were suggested. Responsible: Marcus Koenen will send the rare communities list to participants once it becomes available.

3. Invasive invertebrate species (native and exotic) (High Priority)

a. Invasive invertebrate species represent a threat to important resources within NPS lands.
b. The NPS will receive information needed to mitigate threats to the overall biodiversity found in the parks.
c. Protocols will vary depending on which species are identified.
d. Some invasive species are well known, such as the gypsy moth, which is already being monitored by the region's IPM coordinator and the USDA Forest Service. There may, however, be many more species that are not known to be in the region. Inventory information is lacking. A list of suspected invasive species must be developed for the NCN parks. Once a list has been developed, monitoring needs can be evaluated.
e. Probably will be low cost.
f. Next step: Generate a list of expected invasive species and evaluate the need to monitor them. Responsible: Marcus Koenen will generate a draft list. Participants can review the list and suggest monitoring protocols.

4. Monitor biodiversity (High Priority – especially for rare communities and natural areas)

a. Monitoring biodiversity can provide distribution and abundance information and can support efforts to monitor invasive species, rare species, and potential indicators. It would also provide essential information to properly manage rare communities.
b. The NPS will receive information needed to preserve its overall biodiversity.
c. Protocols were discussed and ranked (Table 6).
d. Biodiversity of invertebrates is largely unknown because of very limited inventory work.

e. Will be high cost because of the numerous species (possibly over 30,000) and inventory protocols needed to cover all species.
f. Next step: The workgroup listed families that should be covered by monitoring biodiversity: butterflies, microhymenoptera, ground beetles, orthopterans, bees, moths, ants, and molluscs. Many other groups were listed and the workgroup decided to list monitoring protocols instead (Table 6). Responsible: Marcus Koenen will refine the list of monitoring protocols below and provide information on which types of invertebrates can be sampled using each. Protocols will have to be developed for each area where they are to be applied. Multidisciplinary teams will need to be formed to develop each protocol.

Table 6. Invertebrate biodiversity monitoring protocols matrix*

Protocol	**Easy to implement**	**Inexpensive**	**Able to monitor a relatively large number of species**
Malaise			x
Bowls	x	x	x
Light Trapping (blacklight and mercury)			x
Bait	x	x	
Pitfalls	x		
Soil Cores and Leaf Litter		x	
Beating and Sweeping (day and night)		x	
Vacuum			x
Visual Searches		x	
Hand Picking		x	
Canopy Sampling			
Butterfly Trapping			

* Note that this table is a gross oversimplification. It will need to be reviewed and discussed further before using it to set priorities.

Sampling protocol must consider:

i. physiographic region (the parks occur in four physiographic regions)

ii. ecological role (each group should be sampled if possible)
-decomposers
-detritivores
-herbivores
-omnivores
-parasites
-pollinators

-predators
-soil aerators

iii. identify to species level whenever possible

iv. sample for main phyla
Annelida (worms and kin)
Arthropoda (insects and kin)
Bryozoa (moss animals)
Cnidaria (jellyfish and kin)
Mollusca (molluscs)
Nematoda (round worms)
Platyhelminthes (flatworms)
Porifera (sponges)
Tardigrada (waterbears)

The workgroup also considered Alveolates:
Protozoa (potozoans)

v. habitats
-spring seeps along fall line
-magnolia bogs
-peculiar habitats
-exemplary occurrences of common habitats
-rare communities as will be identified by RTE workgroup

v. sampling intervals

vi. redundancy of sampling points/sites

5. Evaluate management and restoration activities (Very High Priority because of benefit to park management)

a. Monitoring invertebrates can provide immediate feedback to habitat management and restoration efforts.
b. The NPS could receive important feedback on the success of management and restoration efforts because many kinds of invertebrates typically respond quickly to habitat changes. In addition, many species are easily sampled.
c. Protocols will vary depending on site and management or restoration effort.
d. There has been limited inventory work, making some evaluation difficult. Restoration and management sites could, however, be compared to reference sites.
e. Will be high cost to cover all species.
f. Next step: Inventory information is needed to compare restoration to historic invertebrate communities. Responsible: Future monitoring of restoration and management efforts should be reviewed by invertebrate specialists to evaluate for the suitability of monitoring for

invertebrates. Marcus Koenen will complete a list of all restoration activities and the group will evaluate them for potential invertebrate monitoring.

Additional benefits: Scientists could gain publishable research information if they could perform adequate before-, during-, and after-restoration samples. In addition, scientists would need adequate sampling of the restored site and adjacent sites over a few years to make a strong ecological study. Parks would benefit by gaining information on management and restoration efforts. The data would support other monitoring needs for rare species and indicator species, and it could provide new inventory data. The information could be used to develop checklists and field guides, and it could be used for interpretive programs highlighting park management efforts and the benefit to overall biodiversity.

Management and restoration examples:

i. Grassland Restoration - Manassas Battlefield Park. Manassas is returning approximately 300 acres of grassland to native grasses and forbs. Monitoring invertebrates should provide information on how the park can maintain both an open field and enhance invertebrate biodiversity.

Potential indicator groups: alveolates, annelids, arthropods, molluscs, and nematodes.

Protocols: handpicking, Malaise trapping, sweeping, soil-core sampling and visual searching. A park manager will need to coordinate field technicians with the help of biologists. Taxonomists are needed to aid with identifications. There are likely to be thousands of species in these meadows.

Sampling protocol consideration: sampling sites (hilltop, depression, edge, mowing regimes, sample size).

ii. Kingman Lake Restoration – National Capital Parks-East.   Monitoring invertebrates could provide information on how the park can restore a freshwater marsh (largest in DC) and all of its associated biodiversity.

Potential indicator groups: alveolates, annelids, arthropods, molluscs, nematodes, and platyhelminths.

iii. Pyrite Mine Restoration – Prince William Park.   The pyrite mine at Prince William has been restored. The restored site can be compared to invertebrates in the surrounding area.

Potential indicator groups: alveolates, annelids, arthropods, molluscs, and nematodes.

Protocols: hand collecting, soil-core sampling, sweeping, and visual sampling.

iv. Invasive Plant Control – All Parks.   Invasive plant control is taking place in all parks. The Exotic Plant Management Team (EPMT) works from the Center for Urban Ecology. Monitoring could determine the invertebrate response to control efforts.

Potential indicator groups: alveolates, annelids, arthropods, molluscs, nematodes, and waterbears (live in moss, etc.). May also include moss animals, cnidarians, and sponges, if streams are monitored.

Protocols: many. Need to hand-pick monitoring targets/protocols for each site.

6. Inventory (High Priority)

a. Every aspect of monitoring identified above would benefit from an extensive inventory of as many of the alveolate and invertebrate species as possible. An inventory can provide basic information on the park's biodiversity, invasive species, rare species, and potential indicators.
b. The NPS will receive information needed to preserve its overall biodiversity.
c. Protocols are many and depend on the taxon sampled (Table 6). The overall inventory technique, however, would focus on two strategies.

1. Comprehensive inventory of certain groups of alveolate and invertebrate groups.
2. Comprehensive inventory of all groups at select sites.

d. There has been limited inventory work to date.
e. Cost will be high to cover all species.
f.   Next steps:

1. Generate list of expected species. The first phase is to generate as much information as possible from published literature and park and laboratory species lists.
2. Review collections. The second phase is to add information to the list from collections (e.g. Smithsonian Institution).
3. Implement fieldwork. The third phase is to add information from samples obtained from the parks.

Fieldwork should consider the following:

1. Identification of sites for site-specific inventories. Sites should be chosen in both rare or unique communities and exemplary common communities.
2. Funding. Partnerships should be developed to fund sampling at particular sites.
3. Education and outreach should be an integral component.
4. Infrastructure would have to be coordinated (volunteer processing center, bio-blitzes, parataxonomists, field equipment).

Additional Next Step: Develop a list of invertebrate and alveolate (protozoologist) experts in the region.

Facilitator: Marcus Koenen, NPS – NCN I & M Program

Participants: (contact information provided in Appendix B)
Suzy Alberts, Edd Barrows, Cheryl Bright, Sam Droege, Gary Hevel, Dan Kjar, Larry Morse, Richard Orr, Ted Suman, and Jil Swearingen

D. Landscape Workgroup

The landscape workgroup reviewed the conceptual model that had been produced during previous SAC meetings. Clarification of items in the model was provided to those who were new to the workgroup. The landscape area being discussed was the Lower Chesapeake Bay Watershed.

The workgroup discussed the fact that “Resource Component” was confusing and may not portray the same meaning within the landscape group as it does within other workgroups. The “Resource Components” within the conceptual model could be viewed more as “Landscape Features”. The group also discussed that many items could have both good and bad connotations and, therefore, must be viewed within a species specific or goal context. The issue of scale and mapping resolution for specific objectives was discussed but no consensus was reached. There is the capability to monitor different landscapes with a multi-scale approach, and the coarseness of the analysis will determine what questions can be answered. Protocols for all Vital Signs / Indicators in the conceptual model were identified as being available or not. Groups and organizations that are doing similar work were identified as a source of data and / or protocols. Viewshed was added as a landscape “Resource Component”. During later discussion, the workgroup was asked by other breakout groups to revisit the issue of “resistance to exotics” (the ability of a species or habitat to inhibit or prevent the establishment of a particular exotic species) on a landscape scale. It was determined that “resistance to exotics” was imbedded in what the group was discussing already, and that discussing the issue directly would be at a much smaller scale than the Lower Chesapeake Bay Watershed.

The entire model was prioritized using the Prioritization Matrix (Table 7). Raw scores are presented in Table 8. Discussion continued on the second day of the workshop by starting with a review of the previous day’s Prioritization Matrix. Priorities from the model were determined by two methods: total score of the matrix, and the total score minus the matrix: cost consideration. The top four “threats” were the same in both analyses. The group decided to work with the prioritized listed based on the total score because of the similarities between the two analyses and total score accounted for cost.

Monitoring goals and objectives where developed for the top five prioritized “threats” and the “threats” associated with the resource component “viewshed” (Table 9). Monitoring goals and objectives were added for “viewshed”, despite its lower prioritized rank, because it is a topic of considerable interest to National Parks in the NCN. Vital Signs/Indicators were reviewed to determine their compatibility to the newly-developed monitoring goals and objectives.

The group wanted to emphasize the need to disseminate information both within and outside the National Park Service. Much information is already available from other groups and organizations on a landscape scale. Developing a method to integrate/partner the National Park Service with other agencies and organizations will minimize the need to duplicate effort and will demonstrate the National Park Service’s interest in ecosystem-based management.

Table 7. Landscape threat prioritization using the prioritization matrix.

	Significance to Mid-Atlantic[1]:	**Significance to Parks in the National Capital Region[1]:**					**Total Score[2]**
Threat = Stressor/Source Combination; (Resource Component)	Area (5 = most significant)	Area (5 = most significant)	Intensity (5 = most significant)	Urgency (5 = most significant)	Feasibility (5 = easy to implement)	Monitoring Cost (5 = inexpensive)	
Any development, land use practices (corridors)	4.1	4.1	4.0	4.1	4.2	3.4	**23.9**
Any development, habitat fragmentation / amount of edge (forest interior habitat)	4.1	4.1	4.3	4.0	4.2	3.6	**24.3**
Altered disturbance regime, habitat fragmentation / amount of edge (habitat structure (contagion and configuration))	4.6	4.2	4.1	4.1	3.4	3.4	**23.8**
Altered disturbance regime, natural succession, exotics (habitat structure (type, shape, and configuration))	3.6	4.4	4.1	3.7	3.4	2.8	**22.0**
Altered disturbance regime, natural succession, species over-abundance (habitat structure (type, shape, and configuration))	3.3	3.7	3.5	3.6	4.1	3.5	**21.7**
Any development, land use practices (habitat transition zones (edge))	3.2	3.3	2.7	3.0	3.2	3.0	**18.4**
Legislation, land ownership, demographics, fragmentation of decision making (landscape matrix (greater landscape))	4.6	4.5	4.5	4.3	4.2	3.4	**25.5**

	Significance to Mid-Atlantic[1]:	**Significance to Parks in the National Capital Region[1]:**					**Total Score[2]**
Threat = Stressor/Source Combination; (Resource Component)	Area (5 = most significant)	Area (5 = most significant)	Intensity (5 = most significant)	Urgency (5 = most significant)	Feasibility (5 = easy to implement)	Monitoring Cost (5 = inexpensive)	
Land use, land use practices (species specific natural habitats: change in habitat effect)	4.3	4.2	4.0	4.0	3.8	3.6	**23.9**
Land use, land use practices (species specific natural habitats: change in species effect)	3.8	3.8	3.7	3.8	3.6	3.5	**22.2**
Land use, land use practices (total forest habitat: deforestation effect)	4.4	4.0	4.0	3.8	4.5	3.7	**24.4**
Land use, land use practices (Total forest habitat: altered nutrient export effect)	3.6	2.6	2.7	2.6	3.0	2.6	**17.1**
Land use, land use practices (viewshed: cultural / social)	3.4	4.4	3.6	4.0	4.1	3.5	**23.0**

1. All scores, except “Total Score”, represent the landscape groups average score (n=9).
2 “Total Score” is the sum of the average scores. Higher “Total Score” represents the landscape groups overall view of increased priority.

Table 8. Raw scores for the landscape prioritization matrix*.

	Significance to Mid-Atlantic:	Significance to Parks in the National Capital Region:					**Total Score**
Threat = Stressor/Source Combination; (Resource Component)	Area (5 = most significant)	Area (5 = most significant)	Intensity (5 = most significant)	Urgency (5 = most significant)	Feasibility (5 = easy to implement)	Monitoring Cost (5 = inexpensive)	
Any development, land use practices (corridors)	5,5,5, 4,3,5, 3,4,3	4,4,5 3,5,5 3,4,4	4,4,4 4,5,5 3,4,3	3,3,5 4,5,5 3,5,4	5,4,5 3,5,5 4,3,4	3,3,4 3,5,3 3,3,4	
Any development, habitat fragmentation / amount of edge (forest interior habitat)	5,5,5 4,3,5 4,3,3	5,4,4 4,5,4 4,4,3	4,4,5 5,5,4 4,4,4	3,4,5 4,5,4 4,3,4	5,4,5 3,5,4 3,4,5	3,3,4 4,5,3 3,3,5	
Altered disturbance regime, habitat fragmentation / amount of edge (habitat structure (contagion and configuration))	5,5,5 4,5,5 4,4,5	5,4,4 3,5,4 4,4,5	4,4,4 4,5,4 4,3,5	4,4,4 4,5,4 4,3,5	5,3,4 2,5,4 2,3,3	3,3,4 2,5,4 4,3,3	
Altered disturbance regime, natural succession, exotics (habitat structure (type, shape, and configuration))	5,3,4 3,3,5 4,4,2	5,4,5 4,5,4 5,5,3	4,4,5 4,5,3 4,4,4	4,3,4 4,4,3 5,3,4	5,4,1 2,5,4 4,4,2	3,4,2 3,3,4 3,2,2	
Altered disturbance regime, natural succession, species over-abundance (habitat structure (type, shape. And configuration))	3,3,4 3,3,4 3,3,4	3,4,3 3,5,4 3,4,5	3,3,4 3,5,3 3,3,5	3,3,4 3,4,3 5,3,5	5,4,4 4,5,4 3,4,4	3,4,4 3,3,5 3,4,3	
Any development, land use practices (habitat transition zones (edge))	5,4,5 3,1,5 3,2,1	5,4,5 2,3,4 3,2,2	4,3,3 3,1,4 3,3,1	5,3,4 3,1,4 3,2,2	5,5,1 3,5,3 3,2,2	3,3,1 2,5,5 3,3,2	
Legislation, land ownership, demographics, fragmentation of decision making	5,5,5 5,5,5 4,4,4	5,5,5 5,4,4 4,4,5	5,4,5 5,4,4 4,5,5	5,4,5 5,3,3 4,5,5	5,5,5 4,5,5 4,4,1	3,4,4 3,5,5 3,3,1	

(landscape matrix (greater landscape))							
Land use, land use practices (species specific natural habitats: change in habitat effect)	5,4,5 4,5,5 4,3,4	5,4,4 4,5,4 4,4,4	5,4,3 4,5,4 3,4,4	5,4,3 4,5,3 3,5,4	5,4,3 3,5,4 3,4,4	3,3,5 3,5,3 3,4,4	
Land use, land use practices (species specific natural habitats: change in species effect)	3,4,4 4,5,5 4,2,4	3,4,4 4,5,4 4,3,4	3,4,3 4,5,4 3,4,4	5,4,3 4,5,3 3,4,4	3,4,3 3,5,3 3,4,5	2,4,5 4,5,3 3,3,3	
Land use, land use practices (total forest habitat: deforestation effect)	4,4,5 4,5,5 4,5,4	3,4,4 4,5,3 4,5,4	3,4,4 4,5,4 4,5,3	3,4,4 4,5,3 4,5,3	5,4,5 4,5,4 4,5,5	4,3,4 4,5,3 3,3,5	
Land use, land use practices (total forest habitat: altered nutrient export effect)	4,4,4 3,5,5 4,3,1	3,3,3 2,3,3 3,3,1	3,3,3 3,3,3 3,3,1	3,3,3 2,3,3 3,3,1	3,3,3 2,5,4 3,3,1	2,2,2 3,4,4 3,3,1	
Land use, land use practices (viewshed: cultural / social)	3,3,4 4,3,4 3,2,5	5,3,4 5,5,5 4,4,5	5,3,2 4,3,4 4,3,5	5,3,4 5,4,3 4,3,5	5,4,3 4,5,5 4,4,3	2,4,4 3,5,4 3,3,4	

* An individuals scoring can be followed throughout the table as the first score in each box is representative of individual #1, the second score in each box can be associated with individual #2, etc.

Table 9. Monitoring goals and objectives to priority threats for landscape resources.

THREAT=Stressor/ Source Combination; (Resource Component)	**VITAL SIGN/ INDICATOR**	**GOALS FOR MONITORING EACH THREAT**	**OBJECTIVES**
Land ownership, demographics, legislation, fragmentation of decision making (landscape matrix)	Census data; size of land holding; jurisdictional boundaries	Monitor environmental decision making	Monitor the public and private demographics of land ownership jurisdictions within the Lower Chesapeake Bay Watershed for 5 years.
Land use, land use practices (total forest habitat)	1) Forest habitat types; 2) Bird Community Index	Monitor forest habitat types	Monitor the % cover of forest habitat types within the Lower Chesapeake Bay Watershed for 5 years.
Any development, habitat fragmentation / amount of edge (forest interior habitat)	Bird Community Index	Monitor quality of forest interior habitat	Monitor status and trends of forest interior birds to determine quality of forest interior habitat within the Lower Chesapeake Bay Watershed for 5 years.
Any development, habitat fragmentation / amount of edge (forest interior habitat)	Amount of forest interior habitat; size / edge index; distance between habitat	Monitor quantity of forest interior habitat	Monitor the number of forest interior patches of greater than or equal to 5000 ha within the Lower Chesapeake Bay Watershed for 5 years.
Any development, land use practices (corridors)	Connectivity of habitat of interest; # of breaks in corridor	Monitor the connectivity of green and blue space	Monitor the percent of protected, number of patches, and contiguity of green and blue space within the Lower Chesapeake Bay Watershed for 5 years.
Land use, land use practices (species specific natural habitats)	Change in % of any species specific habitat; Bird Community Index; percentage of impervious surface	Monitor species specific natural habitat	Monitor percentage and distribution of the targeted species suitable habitat within the Lower Chesapeake Bay Watershed for 5 years.
Land use, land use practices (viewshed)	Numerous indicators can be incorporated into the viewshed analysis program	Monitor the viewshed	Monitor the number of physical structures viewable from park units and other green space within the Lower Chesapeake Bay Watershed for 5 years.

Comments received from other participants concerning the landscape monitoring goals and objectives during the “Collaborative Approach” session on day 3 of the workshop:

1. Note that some corridors will encourage interior type species, but other corridors (many) will encourage disturbance species
2. There are interior habitats for trees as well as birds. Some tree species, and hence the vegetation types dominated by them, tend to require larger areas than others. Ecologists and foresters refer to these as tolerant species – tolerant of shoot competition (for light) and root competition (for water and other nutrients). This results in greater acres needed for regeneration than needed by intolerant and intermediate tolerance species. In fact, these species are not only tolerant, but they require that competition for regeneration.
3. Soundsheds – Desirable/Natural Sounds v. Intrusive/Non-natural Sounds
4. What constitutes the "Lower" Chesapeake Bay Region? Is Catoctin included?
5. USDA Forest Service does a forest landowner survey that assesses size of ownership, owner objectives, and owner demographics. One owner is sampled for each 2428 ha of forest – good for regional analyses.
6. Maryland has a layer of ownership boundaries – means of assessing parcelization.

Lastly, the workgroup identified organizations that have already identified protocols and are monitoring varrying aspects of the landscape.

Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource	Indicator/ Vital Sign	Protocols	Source of Protocols and Information
Corridors	Land use practices	Any Development	Habitat Fragmentation, Increase in Exotics, Increase in Edge.	High	Connectivity of habitat of interest; # of Breaks in Corridor	Analysis of USGS Landcover Dataset	Maryland Greenways; County Planners; Chesapeake Bay Program; GAP
Forest Interior Habitat	Habitat Fragmentation / Amount of Edge	Any Development	Loss of Habitat and species through habitat degradation	High	Bird Community Index; Amount of Forest Interior Habitat; Size v. Edge Index; Distance between Patches	Yes	EPA (for BIC); USFS; GAP
Habitat Structure (Contagion and configuration)	Habitat Fragmentation / Amount of Edge	Altered Disturbance Regime	Habitat degradation, loss of species and ecosystem functions	High / Medium	Quantify contagion and connectivity for habitats of interest	Software is available but for smaller scale	Chesapeake Bay Program-Resource Land Group

Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource	Indicator/ Vital Sign	Protocols	Source of Protocols and Information
Habitat Structure (Type, Shape, and configuration)	Exotics; Natural Succession	Altered Disturbance Regime	Habitat degradation, loss of species and ecosystem functions	Variable	Quantify fragment size distribution and perimeter: area ratios for habitats of interest.	Yes	GAP; USFS (FIA); EPA Region III
Habitat Structure (Type, Shape, and configuration)	Species Over-abundance; Natural Succession	Altered Disturbance Regime	Habitat degradation, loss of species and ecosystem functions	Variable	Quantify habitats of interest (map and analyse habitats of interest for structure and composition); Density of species of interest.	Yes	RESAC: Washington Consortium; BRD
Habitat Transition Zones (Edge)	Land Use Practices	Any Development	Loss of Habitat and species	Low	Quantify soft edge and early successional habitat vs. Hard edge; Riparian Buffers (map)	Air Videography (transects across Landscape)	
Landscape Matrix (Greater Landscape)	Fragmentation of Decision Making	Legislation; Land ownership; Demographics	Altered ecosystem structure and function	High	Juxtaposition of legislative jurisdictions (mapping jurisdictions); Juxtaposition of zoning intensities	Tax Maps; Census Data; Size of Private Inholdings; Conservation Easments	Chesapeake Bay Program; GAP; State Maps; VA Tax Maps; US Dept of Census; VA Heritage (easments)

Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource	Indicator/ Vital Sign	Protocols	Source of Protocols and Information
Species specific natural habitats	Land use practices	Land Use	Change of habitat Availability	High	Change in % of any species-specific habitat; Bird Community Index; % of Impervious Surfaces; Riparian Buffer	Species Models for Verterbrates (GAP); Opinion / Viewpoint review analysis (UMD and VA Tech)	GAP; Non-profits; Fairfax County; Towson University (Urban Sprawl Study); MD TNC; NPS Region
Species specific natural habitats	Land use practices	Land Use	Change in Species	High	Presence and Absence of Particular Species / Taxa	Yes	GAP; Chesapeake Bay Program; State, Fed, TNC, BRD
Total Forest Habitat	Land use practices	Land Use	Deforestation	High	Forest Habitat Type; Bird Community Index	Yes	GAP; USFS; NPS Region; EPA; Fairfax County; American Rivers; MBSS (& VA & WV counterparts)
Total Forest Habitat	Land use practices	Land Use	Altered rates of nutrient export	High	Bird Community Index; % agriculture at low topographic (slope) positions; Amount of impervious surface	Yes	EPA; MD & VA GAP (Slope Model); Towson Univ (Urban Sprawl study; Impervious surface)
Viewshed	Land use practices	Land use	Physical Alteration of Habitat Components and Topography	High	Viewshed Analysis	Yes	USFS Scenery Management System; Utility Companies

Facilitator: John Sinclair, NPS – NCN I & M Program

Participants: Jennifer Allen, Betsy Chittenden, Danielle Denenny, Sean Denniston, Pat Bradley, Stephanie Flack, Moonsun Jeong, Mellissa Kangas, Don Owen, Scott Southworth, Jim Sherald, and Jeff Waldon.

E. RTE Workgroup

Outcomes:

1. Evaluate and refine the species ranking criteria.
2. Generate a list of RTE experts to include in the peer review process.
3. Make a plan for refining the list of species and communities ranked by regional importance for rarity.
4. Develop criteria for selection of monitoring sites.
5. Make a plan for creating a list of threats specific to populations at significant sites or significant communities.
6. Make a plan for developing short- and long-term goals for monitoring RTE populations.

Discussion

Interviews with park resource managers led to a list of over 600 species of concern. Given that it would be impossible to develop conceptual models for each species, the RTE workgroup decided that it was necessary to refine the criteria to identify RTE species before conceptual models could be developed. The group drafted criteria to prioritize species of concern and built a preliminary conceptual model for animal species. In addition, the workgroup began to discuss a site-based monitoring approach for plant species and vegetation communities.

In order to meet the outcomes listed above the breakout session discussed the following:

Species Ranking Criteria

The group reviewed the criteria developed by the SAC RTE workgroup for prioritizing the species to be considered for monitoring. The group confirmed the importance and appropriateness of the four criteria and added an additional one (#5 below). The revised criteria follow.

1. Federally listed species and Maryland listed animals
2. G1 and G2
3. G3/S1-S3 (number of occurrences in state)
4. G4/S1 (number of occurrences in state; this criteria was developed to be of use to the parks for setting their priorities but would not necessarily be a high priority for the I & M program).
5. Other species by nomination**

** The Nature Conservancy's eco-regional plans may be sources of information on species for nomination. Examples of "other species by nomination" could include:

- A species indicative of a long-term trend that is currently not threatened
- A species of unique/unusual significance to a location
- A non-native species which may threaten other species in the future

Refined Species and Communities List

The workgroup created a list of experts to include in the next round of peer review to refine the species and communities list for potential monitoring. The individuals to contact include:

Specialist	Specialty
Chris Lea	Vegetation Ecologist
Gwen Brewer	Heritage Ecologist
Lynn Davidson	Heritage Ecologist
Thomas Pauley	Herpetologist
Cris Flemming	Vegetation Ecologist
Gary Flemming	Vegetation Ecologist
Jim Lawrey	Lichen Specialist
Someone for mosses	
Rita Villella	Mussels
Chris Frye	Vegetation Ecologist
Jim McCann	Heritage Zoologist
Ed Thompson	Herpetologist
Allen Belden	Heritage Botanist
Karene Motivans	
Jason Harrison (communities)	Heritage Ecologist
Ken Hotopp	
Kathy McCarthy	
Dick Wiegand	Heritage Botanist
Dan Feller	Heritage Entemologist
Rich Raesly	Aquatic Ecologist
Richard Orr	Entemologist
William Lamp	

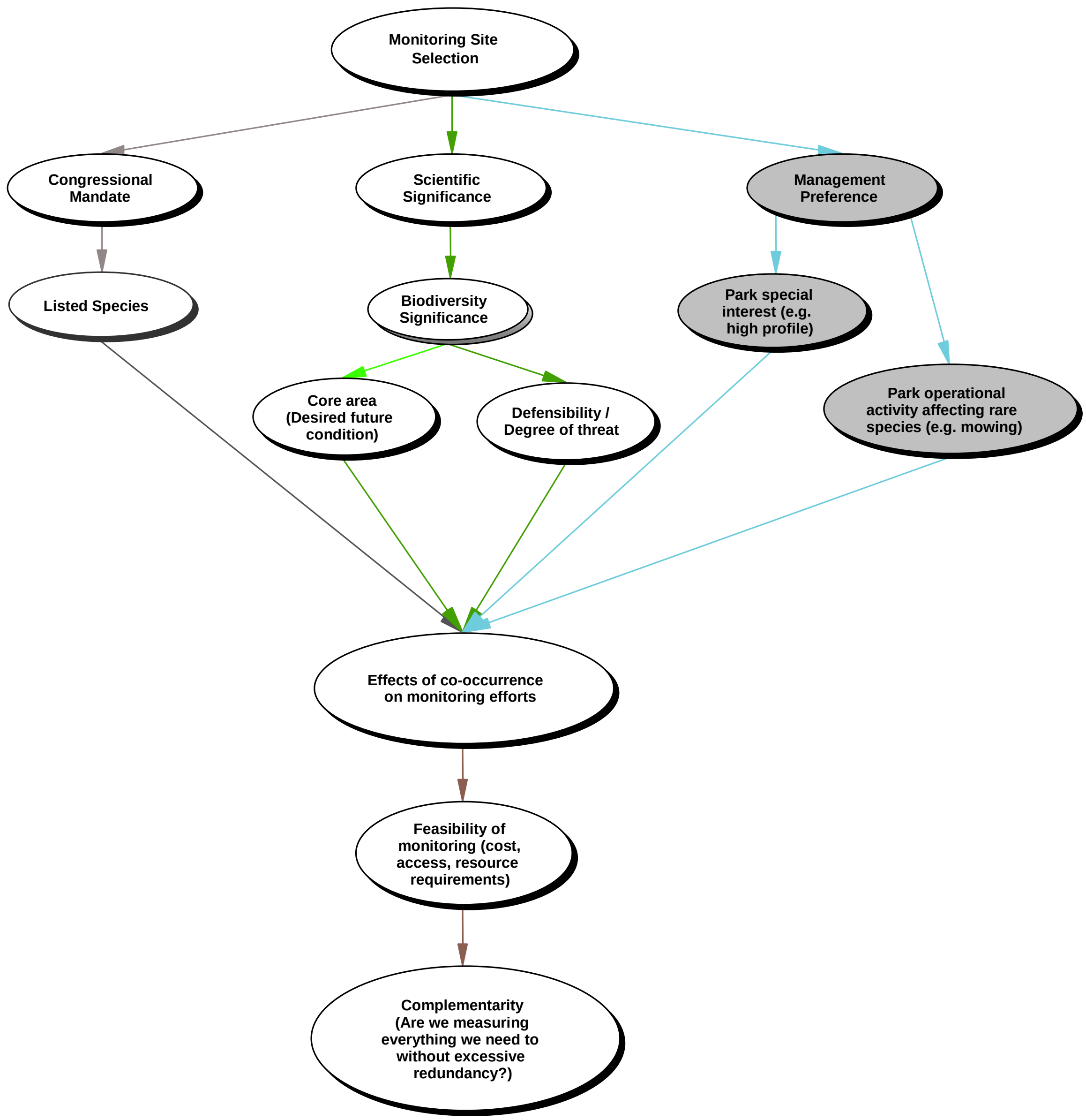
Monitoring Site Selection Criteria

The group described the criteria for site selection recognizing that selection may be instigated by legislative mandate, management preference, or scientific significance. A monitoring site was defined as:

1. An area where one or more species or communities to be monitored are present;
2. The critical area needed by a species for its life history;
3. The area where ecological processes must be at play for a species to persist.

Figure 1 illustrates the criteria for consideration in selecting monitoring sites.

Figure 1. Criteria for selecting monitoring sites for RTE Species.



Follow-up Actions

Because the group did not have sufficient data to complete the process of selecting sites, defining threats and drafting goals, it articulated the following plan to complete these tasks.

1. Update the RTE Species Matrix with the data from NatureServe and distribute it to experts for peer review.

   Lead: Marcus Koenen
   Deadline: October 1, 2002

2. Generate a list of possible monitoring sites based on NatureServe data.

   Lead: Marcus Koenen
   Deadline: October 1, 2002

3. Obtain a list of rare vegetation communities present in parks from Heritage organizations.

   Lead: Ellen Gray
   Deadline: October 31, 2002

4. Peer review conducted by SME's. (Species and communities list, monitoring sites)

   Deadline: October 31, 2002

5. Meeting: SAC RTE workgroup
   Outcome of meeting:
   1. Select sites from the computer-generated list

   Lead: Diane Pavek
   Meeting date: November, 2002

6. Meeting: RTE workgroup & park natural resources managers
   Outcomes of meeting:
   1. Identify threats specific to each site
   2. Establish short- and long-term goals
   3. Establish monitoring objectives

   Lead: Diane Pavek
   Meeting date: Second week of January, 2003

7. Meeting: SAC RTE workgroup
   Outcomes of meeting:
   1. Identify monitoring methods and protocols
   2. QA/QC measures
   3. Evaluation mechanisms

Lead: Diane Pavek
Meeting date: Feb/March 2003?

Future Considerations

- How will we monitor the continued presence of species? What is the standard?
- Gap: No group in this project is addressing the monitoring of exemplary vegetation communities (for control purposes).

Facilitator: Sue Thomas, Avatar, Inc.

Participants: (contact information provided in Appendix B)
Gwen Brewer, Dianne Ingram, Diane Pavek, Larry Morse, Bill Hebb, Stephanie Flack, Mike Thompson, Kent Schwartzkopf, Doug Samson, and Rita Villella.

F. Vegetation Workgroup

The workgroup reviewed the conceptual model developed by the SAC vegetation workgroup. A few comments were added to the table, including one new threat (Table 10).

Table 10. Conceptual model of vegetation resources in the NCN.

Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource
Aging hardwoods (eg oak hickory), lichens, conifers	Air pollution (including ozone and acid deposition); increase CO_2 and N (human caused)	Power plant and car emissions	Increased incidence of decline of some species; disease (multiple stress effect), increased vegetation growth (CO_2 and N)	High
Plant species composition	Climate change	Power plant and car emissions, agriculture	Increasing: Sweetgum, loblolly, S. Red Oak, Blackjack Oak, Post Oak, Winged Elm. Decreasing: Sugar Maple, Beech, White Ash, N. Red Oak	Medium
Upland communities - fire; riparian, 1st and 2nd terrace communities--flood	Changes to natural disturbance regimes (fire, flood) human caused	Land use changes inside and outside parks--fire and flood, weather events drives all	Changes in natural species composition/cover, successional changes may (flood) or may not (fire) be disturbance driven	Low
All vegetation communities	Catastrophic disturbance (natural)	Hurricane, tornado, river flooding, ice storm, strong wind, landslides, fire	Soil saturation, biomass loss (limb breakage, defoliation, removal of above-ground portion), soil loss around roots, increased light (from canopy), decreased light (heavy layer of dead and down wood), canopy loss, understory loss, gap creation, increase seed distribution, loss of seed bank, erosion, change in species diversity, change in species composition, increase in non-native species, increase forage for wildlife, loss of wildlife habitat	Low to medium
Riparian and aquatic vegetation	Erosion (stream bank)	Increased impervious surfaces within the watershed, flooding, boat wake (larger rivers), deforestation, agriculture, construction, recreation (vehicles, horseback riding, hikers)	Destruction of stream bank, incising/lowering of stream, addition of sediment	High
Riparian and aquatic vegetation	Erosion (stream channel)	Construction, deforestation	Uprooting of aquatic vegetation, sediment addition in wetland areas downstream; change in flooding regime	High

Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource
Upland vegetation	Erosion (land surface)	Culverts	Removal of substrate and vegetation and deposition of silt downstream	Medium
All vegetation communities	Cultural resources	Overlapping & conflicting legislation	Fragmentation, habitat changes, introduction of chemicals, increase in exotics, change in natural species composition.	Med/high
All vegetation communities, especially rare or sensitive species	Overuse & concentrated use, poaching, littering	Visitors	Soil compaction, trampling of plants, population decline of rare plants, increase in non-natives.	Medium
All contiguous vegetation cover types	Fragmentation	Changes in land use inside & outside parks, park legislation and management	Increased amount of edge, increased non-native plants through corridors, decrease in population size viability	High
All vegetation communities, soil, water quality	Development – external (non-NPS, outside boundaries)	Commercial, residential, utilities	Wildlife habitat fragmentation, changes in hydrology (vernal pools, ephemeral ponds, wetlands), increase in non-native species, erosion, loss of vegetation and change in species composition	High
All vegetation communities, soil, water quality	Development – internal (NPS & others, inside park boundaries)	New facilities, concessions, politics, utilities, maintenance	Wildlife habitat fragmentation, changes in hydrology, increase in non-native species, erosion, wetland drainage, loss of vegetation and change in species composition	High
Native wetlands	Wetland mitigation (creation of new wetlands)	Installation of new facilities, utilities, infrastructure, concessions, maintenance	Hydrology, changes in species composition, displacement of native plants, habitat loss	Medium
Potentially all vegetation types, especially successional areas, grasslands and shrub habitat (seen as politically more expendable than forest)	Politics, greed, homo-centricism, self promotion	Congress, NPS hierarchy, survival instinct	Loss of habitat, fragmentation	High
All types, forests, wetlands, meadows, scrub / shrub	Non-native plants	Accidental & deliberate introduction, horticulture, land use disturbances, dumping, animals	Displacement of native plants, changes in hydrology, changes in soil chemistry, wildlife habitat loss	High
Insect pollinated plant species, especially species specific to certain pollinators	Loss of native pollinators	Loss of habitat	Decline in native species abundance, change in species composition, loss of habitat	Unknown

Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource
Forest understory	White-tailed deer	Lack of predators, and increase in mature forest and edge habitat	Changes in natural species composition/cover, impedes/alters successional changes	High
Marshes	Non-native animals: nutria	Accidental & deliberate introduction	Trampling, grazing, changes in natural plant population sizes	Low
Meadows, forest	Non-native animals: feral cats, dogs, rabbits	Accidental & deliberate introduction	Trampling, grazing, changes in natural plant population sizes, nutrient loading	Low
American beech	Beech bark disease	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics	Low, all tree diseases together medium
American chestnut	Chestnut blight	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics	Low, all tree diseases together medium
American elm, other elms?	Dutch elm disease	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics	Low, all tree diseases together medium
Butternut	Butternut canker	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics	Low, all tree diseases together medium
Flowering dogwood	Dogwood anthracnose	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics	Low, all tree diseases together medium
Hemlock	Hemlock wooly adelgid	Accidental & deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat, increase in exotics	Medium
Maple, elm	Asian longhorn beetle	Accidental & deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat, increase in exotics	Low
Oaks, pine, other trees	Gypsy moth	Accidental & deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat, increase in exotics	High
Veg communities along road edges and beyond	Localized pollutants (salts, spills, mowing, herbecide)	Road management	Damage; change in species composition	

Prioritization

The workgroup prioritized threats using the Prioritization Matrix (Appendix C). The results are presented in the Average Score column in Table 11. A second prioritization technique was employed by the workgroup in order to check the matrix (Rank column, Table 11). Each participant checked off his/her top five threats. The top ten threats with the most checks turned out to be the same ten identified by the Prioritization Matrix. During the prioritization process, stream channel and stream bank erosion were combined into one threat. The ten most significant threats, in decreasing priority order, were: exotic plants, fragmentation, white-tailed deer, external development, politics, internal development, air pollution, stream bank erosion and gypsy moth (tie for eighth place), and overuse (visitor use). All are indicated in the Final Rank column (Table 11).

Table 11. Results of the threat prioritization for vegetation communities in the NCN.

THREAT	**RANK** (based on each person's top five)	**AVERAGE SCORE** (computed across the group)	**FINAL RANK** (based on computed average)
Air pollution	10	21.08	7
Climate change		19.13	
Human-caused change to natural disturbance regime		17.17	
Catastrophic natural disturbance		15.42	
Stream bank erosion	8	20.25	8
Stream channel erosion	8	19.92	
Land surface erosion		17.17	
Cultural resources		18.79	
Overuse	5	20.04	10
Fragmentation	2	24.00	2
External development	4	22.67	4
Internal development	5	21.21	6
Wetland mitigation		16.42	
Politics	5	22.29	5
Non-native plants	1	25.63	1
Loss of native pollinators		15.00	
White-tailed deer	3	23.92	3
Non-native animals		16.27	

THREAT	RANK (based on each person's top five)	AVERAGE SCORE (computed across the group)	FINAL RANK (based on computed average)
Feral animals		15.91	
Beech bark disease		16.71	
Chestnut blight		14.33	
Dutch elm disease		17.96	
Butternut canker		15.83	
Dogwood anthracnose		18.38	
Hemlock wooly adelgid		18.50	
Asian longhorn beetle		14.17	
Gypsy moth	10	20.25	8
Road management		17.25	

Vital Signs, Monitoring Goals and Objectives

The discussion focused on identifying potential vital signs for each of the top ten threats. This was followed by the development of specific goals and objectives for each threat. Table 12 summarizes the vital signs, goals, and objectives developed by the group. Goals and objectives were developed by consensus. Given limited time, the workgroup assigned the development of goals and objectives to the individuals listed in the threats column.

Table 12. Vital signs and monitoring goals and objectives for the ten most significant threats to vegetation communities in the NCN.

THREAT*	VITAL SIGN	GOALS FOR MONITORING EACH THREAT	OBJECTIVES (species, location, time frame, attribute)
Non-native plants	Ratio of exotics to natives, species richness, percent cover of exotics and natives, density/stem counts	Determine the ration of native to exotics	Estimate the species cover in 11 park units yearly until 2008 in 1% of naturally established vegetative areas
Fragmentation	Ratio of edge to interior, patch size, distribution,	Determine the ration of native to exotics	Obtain fragmentation (at various scales) indices using annual

THREAT*	VITAL SIGN	GOALS FOR MONITORING EACH THREAT	OBJECTIVES (species, location, time frame, attribute)
	composition (veg vs urban), proximity (of patches to each other and to development or other fragmenting feature) (see over use)		satellite imagery and aerial photography every 5 years. Develop and maintain georeferenced GIS database of fragmenting features with in each park (road, trails, etc.).
White-tailed deer	Seedling regeneration distribution of species preferred by deer vs. species not preferred by deer; Numbers of seedlings and saplings by height class; Percent of area with adequate regeneration by size class distribution	Identify impact of deer on forest regeneration	Show relationship between seedling regeneration and deer population size
Internal development (first draft of objectives by Chip, Brent, and L.K.)	Percent loss of native vegetation; percent disturbance/loss of topsoil due to development (see external development)	Identify loss of native vegetation.	Maintain GIS layer of internal development and maintained/ landscaped areas (update annually). Characterize vegetation lost (gained) disturbed as a result (see fragmentation).
Politics	Percent superintendents with a resource management experience/background; number of political actions that overturn resource management decisions—number of politically affected management decisions Protocol: number of politically mandated actions that affect the resource per year,	Identify political influence on natural resource management.	Document the number of times per year that political mandates effect resource management decisions and acres lost and other vegetation losses. Track the percent of upper level management with resource management experience over time.

THREAT*	VITAL SIGN	GOALS FOR MONITORING EACH THREAT	OBJECTIVES (species, location, time frame, attribute)
	including the number of times politics prevents the best management of resources		
Internal Development (first draft of objectives by Chip Scott, Brent Steury, and L.K. Thomas)	Vegetation composition change as a function of distance (see fragmentation)	Determine vegetation composition change as a function of distance from development.	Maintain GIS layer of (near) external development (update annually). Identify internal areas likely to be affected by changes in hydrology and weed sources. Monitor vegetation composition changes. (See fragmentation.)
Visitor use (first draft of objectives by Wendy Cass and Ann Brazinski)	Number of social trail extent and condition of existing trails; number of visitors/year	Determine number of social trails.	Estimate the area (length and width) of social trail impacts within the highest visitor use areas at the 11 parks every three years.
Air pollution (first draft of objectives by Dean Walter and Doug Samson)	Number of lichens/plot; species richness, composition, density of lichens/plot/ ozone sensitive species/leaf damage/ thickness of algae layer in lichen over time	Determine number of lichens per plot and species composition. Also determine leaf damage to ozone sensitive species and thickness of algae layers in lichens.	Establish long-term monitoring plot for lichens at a range of sites. Monitor lichen cover and composition and correlate with regional O_3, N_xO_x and S_xO_x levels. Monitor every 5 years to establish trends. Monitor O_3 damage to vascular plants.

THREAT*	VITAL SIGN	GOALS FOR MONITORING EACH THREAT	OBJECTIVES (species, location, time frame, attribute)
Gypsy Moth (first draft of objectives by Chris Lea and Drew Banasik)	Acres defoliated, egg mass density; vegetation composition under defoliated area; mean egg mass size	Determine acres defoliated by gypsy moths and egg mass density. Monitor vegetation composition under defoliated area.	Estimate the number of egg masses (and mean size) in vegetation types susceptible to gypsy moth defoliation. Determine the area of forest tree canopy defoliated that is attributable to gypsy moth. Measure the area and distribution and treatment type of gypsy moth treatment blocks.
Stream bank and channel erosion (first draft of objectives by Sue Salmons and Mikaila Milton)	Number of downed trees and exposed roots; flood plain species composition.	Determine number of downed trees and exposed roots.	Determine the number of fallen trees and exposed roots annually on vertical bank slopes and the change of species composition every 5 years in floodplain habitat.

* Names listed under each threat indicate who developed the associated goal and objectives. If no names are listed, the goal and objectives were developed by the entire workgroup.

Facilitators: Mikaila Milton, NPS – NCN I & M Program and Brent Steury, NPS - NACE

Participants: (contact information provided in Appendix B)
Andrew Banasik, Ann Brazinski, Wendy Cass, Cindy Huebner, Chris Lea, Maureen Joseph, Diane Pavek, Doug Samson, Sue Salmons, Chip Scott, L.K. Thomas Jr., and Dean Walton.

G. Water Breakout Session

The Water Workgroup began by reviewing the conceptual model developed by the SAC Water Workgroup to evaluate which stressors actually had an effect on each resource. In addition the workgroup wanted to review possible indicators for each Resource-Stressor combination. Table 13 presents a revised conceptual model including vital sign indicators. Changes to the model include:

1. “Trash” is not a stressor, it is an indicator and should be considered in any physical habitat assessment.
2. “Introduced” was changed to “Non-native” with regard to species. This includes both naturalized species which have an established breeding population, and exotic species recently introduced such as the snakehead.
3. “Climate Change” is beyond the scope of immediate monitoring more evident with a couple hundred to a thousand years of sampling.

Table 13. Revised conceptual model including threats, ecological effects, and vital signs to aquatic resource components within the NCN.

<table>
<tr><th>Resource Component</th><th>Stressor</th><th>Ecological Effects</th><th>Threat Priority</th><th>General Indicator/ Vital Sign*</th></tr>
<tr><td>Fish</td><td></td><td></td><td></td><td>Sedimentation, creel census, temperature, physical habitat, DO, macroinvertebrates, fish population, brook trout or other indicator species, disease indicators in fish, vegetation/water quality monitoring, changes in habitat makeup (loss of grasses, etc.)
Core Water Parameters (CWP), Fish Index (AS), Physical Habitat Index (PHI), Creel Census (CC)</td></tr>
<tr><td></td><td>Flow regime (low)</td><td rowspan="9">↓ Biodiversity,
Generalists:Special-ists changes,
↑ Tolerant species,
↓ Intolerant species,
↑ Non-native species,
↑ Less desirable species,
Fish kills,
Hybridization,
↓ Reproductive success,
Change in migration patterns or spawning time or location,
Disease/mutation rate ↑,
Change in ratio of stenothermal and eurythermal species,
Population ↓,
Disrupted age structure</td><td>H</td><td>CWP, AS, PHI, CC</td></tr>
<tr><td></td><td>Flow regime (high)</td><td>H</td><td>CWP, AS, PHI</td></tr>
<tr><td></td><td>Water quality – nutrients</td><td>M</td><td>CWP, AS</td></tr>
<tr><td></td><td>Water quality – toxics</td><td>?</td><td>CWP, AS</td></tr>
<tr><td></td><td>Water quality – sediments</td><td>H</td><td>CWP, AS, PHI</td></tr>
<tr><td></td><td>Water quality - acid deposition (pH)</td><td>?</td><td>CWP, AS</td></tr>
<tr><td></td><td>Water quality – bacteria and other disease</td><td>M</td><td>CWP, AS</td></tr>
<tr><td></td><td>Water quality - drugs/hormones</td><td>?</td><td>CWP, AS</td></tr>
<tr><td></td><td>Water quality - temperature</td><td>H</td><td>CWP, AS, PHI</td></tr>
</table>

Resource Component	Stressor	Ecological Effects	Threat Priority	General Indicator/ Vital Sign*
	Habitat alteration		H	CWP, AS, PHI
	Deforestation		H	CWP, AS, PHI
	Non-native species		H	AS
	Trampling/compaction		L	CWP, AS, PHI
	Wildlife behavior disruption		L	AS, PHI
	Overfishing/harvesting/collecting		?	AS, PHI, CC
	Hybridization		?	AS
Herps				*Herp habitat, indicator species, frog calling* Physical Habitat Index (PHI) – in this case a combination of PHI, spatial area, & localized LC/LU specifically for herp habitat; indicator species (AS)
	Flow regime (low)	↓ Biodiversity, Generalists:Specialists changes, ↑ Tolerant species ↓ Intolerant species, ↑ Non-native species, ↑ Less desirable species, ↑ Disease/mutation rates, Change in migration pattern or breeding time or location, Population ↓, Disrupted age structure, Reproductive success ↓	H	PHI, AS
	Flow regime (high)		H	PHI, AS
	Water quality - nutrients		M	PHI, AS
	Water quality - toxics		?	PHI, AS
	Water quality - sediments		H	PHI, AS
	Water quality - acid deposition (pH)		?	PHI, AS
	Water quality - source of physical abnormality		?	PHI, AS
	Water quality - temperature		M	AS
	Habitat alteration		H	PHI, AS
	Deforestation		H	PHI, AS
	Non-native species		H	PHI, AS
	Trampling/compaction		L	PHI, AS
	Wildlife behavior disruption		L	PHI, AS
	Overfishing/harvesting/collecting		?	AS
Benthos				*Macroinvertebrate index, physical habitat* Macroinvertebrate index (AS), Physical

Resource Component	Stressor	Ecological Effects	Threat Priority	General Indicator/ Vital Sign*
				Habitat Index (PHI), Core Water Parameters (CWP),
	Flow regime (low)	Biodiversity ↓, Generalists : specialists changes, ↑ Tolerant species ↓ Intolerant species, ↑ Non-native species, ↑ Less desirable species, Population ↓, Change in community structure, Disrupted age structure, ↓ Reproductive success	H	CWP, AS, PHI
	Flow regime (high)		H	CWP, AS, PHI
	Water quality - nutrients		H	ChlorA, AS, PHI
	Water quality – toxics (chloramine?)		?	SWCP, AS, PHI
	Water quality - sediments		H	CWP, AS, PHI
	Water quality - acid deposition (pH)		?	CWP, AS, PHI
	Water quality - drugs/hormones		L	CWP, AS, PHI
	Water quality - temperature		H	CWP, AS, PHI
	Habitat alteration		M	CWP, AS, PHI
	Deforestation		H	CWP, AS, PHI
	Non-native species		H	AS, PHI
	Trampling/compaction		L	AS, PHI
	Wildlife behavior disruption		L	CWP (beaver), AS, PHI
	Overfishing/harvesting/collecting (mussels)		L?	AS, PHI
Plankton - C&O Canal, Kenilworth Aquatic Gardens, ponds/lakes, dammed areas, below dams, side ponds on rivers				*Plankton population, Nutrients* Plankton population as Assemblage Structure (AS) and Chlorophyll A and Silica content (ChlorA/Si)
	Flow regime (slow)	↑ Undesirable and non-native species, Disruption in population cycle and size, Change in biodiversity	H	AS, ChlorA/Si
	Flow regime (fast)		H	AS, ChlorA/Si

Resource Component	Stressor	Ecological Effects	Threat Priority	General Indicator/ Vital Sign*
	Water quality - nutrients		H	AS, ChlorA/Si
	Water quality - toxics		?	AS, ChlorA/Si
	Water quality - sediments		H	AS
	Water quality - acid deposition (pH)		?	AS, ChlorA/Si
	Water quality - bacteria (nutrient competition)		M	AS, ChlorA/Si
	Water quality - temperature		H	AS, ChlorA/Si
	Habitat alteration		H	AS, ChlorA/Si
	Deforestation		H	AS, ChlorA/Si
	Non-native species		H	AS, ChlorA/Si
	Wildlife behavior disruption (beaver)		L	AS, ChlorA/Si
Vegetation, wetlands				*Land Cover in watershed, precipitation/wells, community structure, indicator species, sedimentation* Land Cover in watershed (LC/LU), Ground Water Level (GWL), Community Structure (AS), Core Water Parameters (CWP)
	Flow regime (low)	↓Biodiversity, ↑ Tolerant species ↓ Intolerant species, ↑ Non-native species, ↑ Less desirable species, Change in community structure, ↑ Disease/pest, ↓ Regeneration	H	LC/LU, GWL, AS, CWP
	Flow regime (high)		H	LC/LU, GWL, AS, CWP
	Water quality - nutrients		M	LC/LU, GWL, AS, CWP
	Water quality - toxics		?	LC/LU, GWL, AS, CWP
	Water quality - sediments		H	LC/LU, GWL, AS, CWP
	Water quality - acid deposition (pH)		?	GWL, AS, CWP
	Water quality - bacteria		L	GWL, AS
	Water quality - drugs/hormones		L	AS
	Water quality - temperature		H	LC/LU, GWL, AS, CWP
	Habitat alteration		L	AS
	Deforestation		H	LC/LU, GWL, AS, CWP
	Non-native species		H	AS

Resource Component	Stressor	Ecological Effects	Threat Priority	General Indicator/ Vital Sign*
	Trampling/compaction		M	AS
	Wildlife behavior disruption		L	AS
	Overfishing/harvesting/collecting		?	AS
	Hybridization		L	AS
Groundwater				*Flow, water quality, bacteria, toxics, water chemistry, nutrients, wells, groundwater level* Core Water Parameters, especially flow and water quality (CWP), Specialized Water Chemistry Parameters such as bacteria, toxics, water chemistry, and nutrients (SWCP), Groundwater Level (GWL)
	Flow regime (low)	↑ Impairment of water quality, water supply, and physical habitat (ie algal blooms), including alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↓ Infiltration, ↓ Recreational opportunities (swimming, fishing, etc), and aesthetics, Altered biological communities Altered behavior of wildlife	H	CWP, GWL
	Flow regime (high)		H	CWP, GWL
	Water quality - nutrients		M	CWP, SWCP, GWL
	Water quality - toxics		?	CWP, SWCP, GWL
	Water quality - sediments		H	CWP, SWCP, GWL
	Water quality - acid deposition (pH)		?	CWP, SWCP, GWL
	Water quality - bacteria		H	CWP, SWCP, GWL
	Water quality - drugs/hormones		?	CWP, SWCP, GWL
	Water quality - temperature		H	CWP, SWCP, GWL
	Habitat alteration		H	CWP, SWCP, GWL
	Deforestation		H	CWP, SWCP, GWL
	Non-native species		H	CWP, SWCP, GWL
	Trampling/compaction		L	CWP, SWCP, GWL
	Wildlife behavior disruption		L	CWP, SWCP, GWL
	Groundwater mining		?	CWP, GWL
Physical habitat				*Stream geomorphology, sedimentation, assessment (EPA, etc.)* Physical Habitat Index (PHI), Sedimentation (S), Core Water Parameters, specifically flow

Resource Component	Stressor	Ecological Effects	Threat Priority	General Indicator/ Vital Sign*
				(CWP)
	Flow regime (low)	Scouring, Bank instability/mass wasting, Sedimentation, Altered stream morphology, Altered temperature regime, Altered canopy cover Altered flow regime	H	CWP, PHI,
	Flow regime (high)		H	CWP, PHI,
	Water quality - sediments		H	CWP, PHI, S
	Habitat alteration		H	CWP, PHI, S
	Deforestation		H	CWP, PHI, S
	Non-native species		H	NEED INDICATOR
	Trampling/compaction		H	PHI
	Wildlife behavior disruption		L	CWP, PHI, S
Vernal/ ephemeral pools - except for the implications of flow regime, indicators are the same as wetlands and groundwater. There will be a time consideration of when to sample.				*Number and size of pools, groundwater, amphipods, reproductive success of herps,* Specialized Water Chemistry Parameters such as ANC and micronutrients (SWCP), Groundwater Level (GWL), Core Water Parameters (CWP)
	Flow regime (low - bad)	Change in number, timing, and presence of pools, ↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant species and ↓ Intolerant species, ↑ Non-native species, ↑ Less desirable species, Change in community structure, Diseased/pest increase, ↓ Regeneration	H	CWP, GWL, SWCP
	Flow regime (high - good)		H	CWP, GWL, SWCP
	Water quality - nutrients		L	CWP, GWL, SWCP
	Water quality - toxics		?	CWP, GWL, SWCP
	Water quality - sediments		H	CWP, GWL, SWCP
	Water quality - acid deposition (pH)		?	CWP, GWL, SWCP
	Water quality - bacteria		M	CWP, GWL, SWCP
	Water quality - drugs/hormones		?	CWP, GWL, SWCP
	Water quality - temperature		H	CWP, GWL, SWCP
	Habitat alteration		L	CWP, GWL, SWCP

Resource Component	Stressor	Ecological Effects	Threat Priority	General Indicator/ Vital Sign*
	Deforestation		H	CWP, GWL, SWCP
	Non-native species		H	CWP, GWL, SWCP
	Trampling/compaction		L	CWP, GWL, SWCP
	Wildlife behavior disruption		L	CWP, GWL, SWCP
Riparian zone / floodplain				*Assessment, Aerial photography* Sediment (S); Assemblage Structure (AS), including vegetation structure, community structure, biomass, and age structure; Land Cover/Land Use (LU/LC); Physical Habitat Index (PHI) specifically watershed, riparian and stream morphology; Groundwater Level (GWL)
	Flow regime	↑ Impairment of water quality, water supply, and physical habitat (i.e. algal blooms), including alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, Change in vegetation community due to altered flooding regime	H	AS, GWL, LC/LU, PHI
	Runoff - nutrients		L	AS, LC/LU, PHI
	Runoff - toxics		?	AS, LC/LU, PHI
	Runoff - sediments		H	AS, LC/LU, PHI, S
	Runoff - acid deposition (pH)		?	AS, LC/LU, PHI
	Habitat alteration		H	AS, GWL, LC/LU, PHI
	Deforestation		H	AS, GWL, LC/LU, PHI
	Non-native species		H	AS, GWL, LC/LU, PHI
	Trampling/compaction		H	AS, GWL, PHI
	Wildlife behavior disruption		L	AS, LC/LU, PHI

*The original set of suggested vital signs is italicized. The finalized set of vital signs is listed below the original set and abbreviated next to the corresponding threat.

Abbreviations:

BIOLOGICAL

AS - Assemblage Structure: includes community structure, vegetation structure, herp index, fish index, macroinvertebrate index, macroalgae presence/absence and density, plankton population

CHEMICAL

CWP - Core Water Parameters: include temperature, DO, pH, flow/stage/water level, specific conductance, clarity, ANC/alkalinity

PHYSICAL

PHI – Physical Habitat Index: includes stream geomorphology and presence and density/cover of trash. Perhaps also include presence/absence of macro algae. Physical Habitat Index for herps may include a combination of PHI, spatial area, and localized LU/LC.

SPECIALIZED WATER CHEMISTRY PARAMETERS

ClorA/SI - Chlorophyll A/Silica: indicates plankton communities – chlorophyll A for phytoplankton and SI for diatoms
CC - Creel Count: includes what is being caught, how many, how big, where and with what
GWL - Groundwater Level: includes precipitation and well level. Groundwater flux would be good for herps and vernal pools.
LU/LC - Land User/Land Cover: includes water/riparian/stream morphology, land use, vegetation, impervious surface
S – Sedimentation: includes sediment accumulation and water column load of sediment
SWCP - Specialized Water Chemistry Parameters: include specific heavy metals, toxics, nitrogen, and phosphorus forms

Ecological Indicators/Vital Signs

The National Park Service Water Resources Division (WRD) has decided that a required minimum parameter suite (referred to as "core parameters") would be appropriate and most consistent with the broader goals of the I & M Program. They recommend that temperature (T), specific conductance (SC), pH, and dissolved oxygen (DO) be taken within the water column, and, at a minimum, some qualitative estimate or assessment of flow/discharge (low, medium, high, flood stage, etc.) also be documented (or a quantitative flow estimate be approximated) at all flowing freshwater monitoring sites in the program. At non-flowing freshwater monitoring sites (lakes, reservoirs, etc.), a qualitative assessment of stage/level of the waterbody should be reported along with some minimum profiling of the water column of the required parameters (*Draft Recommendations for Core Water Quality Monitoring Parameters and Other Key Elements of the NPS Vital Signs Program Water Quality Monitoring Component*, Freshwater Workgroup Subcommittee, June 14, 2002, Fort Collins, Colorado).

Threat Prioritization

The workgroup listed tall of the threats on the Prioritization Matrix (Appendix C) and assigned values. It was noted that all of the top six threats were products of urbanization:

1. Flow Regime
2. Sediment
3. Deforestation
4. Habitat Alteration
5. Nutrients
6. Temperature

It was also noted that the top six stressors affect all of the resources identified in the conceptual model (Table 14), indicating that this prioritization method was not beneficial for determining monitoring priorities. We then looked at the stressors affecting each resource versus the possible indicators (Table 15) and found that, for each resource, 2 to 4 indicators were able to capture the effects of all of the stressors. Our approach to determine monitoring priorities is outlined under Next Steps below.

Table 14. List of stressors and the aquatic resources they affect.

		WATER RESOURCE COMPONENTS								
Stressor		**Fish**	**Benthos**	**Herps**	**Plankton**	**(Wetland, Channel) Vegetation**	**Riparian zone / Floodplain**	**Groundwater**	**Physical Habitat**	**Vernal / Ephemeral Pools**
Flow Regime	low (base)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	high (storm)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Water Quality	nutrients	Y	Y	Y	Y	Y	Y (runoff)	Y		Y
	sediment	Y	Y	Y	Y	Y	Y (runoff)	Y	Y	Y
	temperature	Y	Y	Y	Y	Y		Y		Y
Habitat alteration		Y	Y	Y	Y	Y	Y	Y	Y	Y
Deforestation		Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 15. Stressors to aquatic resources and their possible indicators

		Indicators																			
		Assemblage Structure (AS)					Core Water Parameters (CWP)			Physical Habitat Index (PHI)			Land Cover / Land Use (LC/LU)	Creel Count (CC)	ChlorA / Si		Groundwater Level (GWL)		Sediment (S)		SWCP
Resource Component	**Stressors**	Community Structure (CS)	Vegetation Structure (VS)	Fish Index (FI)	Herp Index (HI)	Benthic Macroinvertebrate Index (MI)	Core Water Parameters (CWP)	Flow (F)	Water Level (WL)	Stream Geomorphology (SGM)	Watershed / Riparian / Stream Morphology (WRSM)	Physical Habitat Index (PHI)	Land Cover / Land Use (LC/LU)	Creel Census (CC)	Chlorophyl A (ChlorA)	Silica (Si)	Groundwater Level (GWL)	Precipitation / Well Level (PCW)	Sediment (S)	Sediment Accumulation (SA)	Specialized Water Chemistry Parameters (SWCP)
Fish																					
	Flow regime			X			X					X									
	Water quality – nutrients			X			X					X									
	Water quality – toxics			X			X														
	Water quality – sediments			X			X					X									
	Water quality - acid deposition (pH)			X			X														
	Water quality – bacteria and other disease			X			X														
	Water quality – drugs/hormones			X			X														
	Water quality - temperature			X			X					X									
	Habitat alteration			X			X					X									
	Deforestation			X			X					X									
	Non-native species			X			X														
	Trampling/compaction			X			X														
	Wildlife behavior disruption			X			X					X									

		Indicators																			
		Assemblage Structure (AS)					Core Water Parameters (CWP)			Physical Habitat Index (PHI)			Land Cover / Land Use (LC/LU)	Creel Count (CC)	ChlorA / Si		Groundwater Level (GWL)		Sediment (S)		SWCP
Resource Component	Stressors	Community Structure (CS)	Vegetation Structure (VS)	Fish Index (FI)	Herp Index (HI)	Benthic Macroinvertebrate Index (MI)	Core Water Parameters (CWP)	Flow (F)	Water Level (WL)	Stream Geomorphology (SGM)	Watershed / Riparian / Stream Morphology (WRSM)	Physical Habitat Index (PHI)	Land Cover / Land Use (LC/LU)	Creel Census (CC)	Chlorophyl A (ChlorA)	Silica (Si)	Groundwater Level (GWL)	Precipitation / Well Level (PCW)	Sediment (S)	Sediment Accumulation (SA)	Specialized Water Chemistry Parameters (SWCP)
	Overfishing/harvesting/collecting			X								X		X							
	Hybridization																				
Herps																					
	Flow regime				X							X									
	Water quality - nutrients				X							X									
	Water quality - toxics				X							X									
	Water quality - sediments				X							X									
	Water quality - acid deposition (pH)				X							X									
	Water quality - source of physical abnormality				X																
	Water quality - temperature				X							X									
	Habitat alteration				X							X									
	Deforestation				X							X									
	Non-native species				X							X									
	Trampling/compaction				X							X									
	Wildlife behavior disruption				X																
	Overfishing/harvesting/collecting				X																
Benthos																					
	Flow regime					X	X					X									
	Water quality - nutrients					X	X					X									

		Indicators																			
		Assemblage Structure (AS)					Core Water Parameters (CWP)			Physical Habitat Index (PHI)			Land Cover / Land Use (LC/LU)	Creel Count (CC)	ChlorA / Si		Groundwater Level (GWL)		Sediment (S)		SWCP
Resource Component	Stressors	Community Structure (CS)	Vegetation Structure (VS)	Fish Index (FI)	Herp Index (HI)	Benthic Macroinvertebrate Index (MI)	Core Water Parameters (CWP)	Flow (F)	Water Level (WL)	Stream Geomorphology (SGM)	Watershed / Riparian / Stream Morphology (WRSM)	Physical Habitat Index (PHI)	Land Cover / Land Use (LC/LU)	Creel Census (CC)	Chlorophyl A (ChlorA)	Silica (Si)	Groundwater Level (GWL)	Precipitation / Well Level (PCW)	Sediment (S)	Sediment Accumulation (SA)	Specialized Water Chemistry Parameters (SWCP)
	Water quality - toxics (chloramine?)					X						X			X						
	Water quality - sediments					X						X									X
	Water quality - acid deposition (pH)					X	X					X									
	Water quality - drugs/hormones					X	X					X									
	Water quality - temperature					X	X					X									
	Habitat alteration					X	X					X									
	Deforestation					X	X					X									
	Non-native species					X						X									
	Trampling/compaction					X						X									
	Wildlife behavior disruption					X	X					X									
	Overfishing/harvesting/collecting (mussels)					X						X									
Plankton																					
	Flow regime	X													X	X					
	Water quality - nutrients	X													X	X					
	Water quality - toxics	X													X	X					
	Water quality - sediments	X																			
	Water quality - acid deposition (pH)	X													X	X					

		Indicators																			
		Assemblage Structure (AS)					Core Water Parameters (CWP)			Physical Habitat Index (PHI)			Land Cover / Land Use (LC/LU)	Creel Count (CC)	ChlorA / Si		Groundwater Level (GWL)		Sediment (S)		SWCP
Resource Component	Stressors	Community Structure (CS)	Vegetation Structure (VS)	Fish Index (FI)	Herp Index (HI)	Benthic Macroinvertebrate Index (MI)	Core Water Parameters (CWP)	Flow (F)	Water Level (WL)	Stream Geomorphology (SGM)	Watershed / Riparian / Stream Morphology (WRSM)	Physical Habitat Index (PHI)	Land Cover / Land Use (LC/LU)	Creel Census (CC)	Chlorophyl A (ChlorA)	Silica (Si)	Groundwater Level (GWL)	Precipitation / Well Level (PCW)	Sediment (S)	Sediment Accumulation (SA)	Specialized Water Chemistry Parameters (SWCP)
	Water quality - bacteria (nutrient competition)	X													X	X					
	Water quality - temperature	X													X	X					
	Habitat alteration	X													X	X					
	Deforestation	X													X	X					
	Non-native species	X													X	X					
	Wildlife behavior disruption (beaver)	X																			
Vegetation, wetlands																					
	Flow regime	X					X						X					X			
	Water quality - nutrients	X					X						X					X			
	Water quality - toxics	X					X						X					X			
	Water quality - sediments	X					X						X					X			
	Water quality - acid deposition (pH)	X					X											X			
	Water quality - bacteria	X																			
	Water quality - drugs/hormones	X											X					X			
	Water quality - temperature	X					X														
	Habitat alteration	X											X								
	Deforestation	X					X														
	Non-native species	X																			

		Indicators																			
		Assemblage Structure (AS)					Core Water Parameters (CWP)			Physical Habitat Index (PHI)			Land Cover / Land Use (LC/LU)	Creel Count (CC)	ChlorA / Si		Groundwater Level (GWL)		Sediment (S)		SWCP
Resource Component	**Stressors**	Community Structure (CS)	Vegetation Structure (VS)	Fish Index (FI)	Herp Index (HI)	Benthic Macroinvertebrate Index (MI)	Core Water Parameters (CWP)	Flow (F)	Water Level (WL)	Stream Geomorphology (SGM)	Watershed / Riparian / Stream Morphology (WRSM)	Physical Habitat Index (PHI)	Land Cover / Land Use (LC/LU)	Creel Census (CC)	Chlorophyl A (ChlorA)	Silica (Si)	Groundwater Level (GWL)	Precipitation / Well Level (PCW)	Sediment (S)	Sediment Accumulation (SA)	Specialized Water Chemistry Parameters (SWCP)
	Trampling/compaction	X																			
	Wildlife behavior disruption	X																			
	Overfishing/harvesting/collecting	X																			
	Hybridization																				
Groundwater																					
	Flow regime						X	X									X				
	Water quality - nutrients						X	X									X				X
	Water quality - toxics						X	X									X				X
	Water quality - sediments						X	X									X				X
	Water quality - acid deposition (pH)						X	X									X				X
	Water quality - bacteria						X	X									X				X
	Water quality - drugs/hormones						X	X									X				X
	Water quality - temperature						X	X									X				X
	Habitat alteration						X	X									X				
	Deforestation						X	X									X				
	Non-native species						X	X									X				
	Trampling/compaction						X	X									X				
	Wildlife behavior disruption						X	X													
	Groundwater Mining						X	X									X				
Physical habitat																					

		Indicators																			
		Assemblage Structure (AS)					Core Water Parameters (CWP)			Physical Habitat Index (PHI)			Land Cover / Land Use (LC/LU)	Creel Count (CC)	ChlorA / Si		Groundwater Level (GWL)		Sediment (S)		SWCP
Resource Component	**Stressors**	Community Structure (CS)	Vegetation Structure (VS)	Fish Index (FI)	Herp Index (HI)	Benthic Macroinvertebrate Index (MI)	Core Water Parameters (CWP)	Flow (F)	Water Level (WL)	Stream Geomorphology (SGM)	Watershed / Riparian / Stream Morphology (WRSM)	Physical Habitat Index (PHI)	Land Cover / Land Use (LC/LU)	Creel Census (CC)	Chlorophyl A (ChlorA)	Silica (Si)	Groundwater Level (GWL)	Precipitation / Well Level (PCW)	Sediment (S)	Sediment Accumulation (SA)	Specialized Water Chemistry Parameters (SWCP)
	Flow regime							X	X	X		X									
	Water quality - sediments							X	X	X		X									
	Habitat alteration							X	X	X		X									
	Deforestation							X	X	X		X									
	Non-native species							X	X	X		X									
	Trampling/compaction									X		X									
	Wildlife behavior disruption								X	X									X		
Vernal/ephemeral pools																					
	Flow regime						X	X									X				X
	Water quality - nutrients						X	X									X				X
	Water quality - toxics						X	X									X				X
	Water quality - sediments						X	X									X				X
	Water quality - acid deposition (pH)						X	X									X				X
	Water quality - bacteria						X	X									X				X
	Water quality - drugs/hormones						X	X									X				X
	Water quality - temperature						X	X									X				X
	Habitat alteration						X	X									X				
	Deforestation						X	X									X				
	Non-native species						X	X									X				
	Trampling/compaction						X	X									X				

		Indicators																			
		Assemblage Structure (AS)					Core Water Parameters (CWP)			Physical Habitat Index (PHI)			Land Cover / Land Use (LC/LU)	Creel Count (CC)	ChlorA / Si		Groundwater Level (GWL)		Sediment (S)		SWCP
Resource Component	**Stressors**	Community Structure (CS)	Vegetation Structure (VS)	Fish Index (FI)	Herp Index (HI)	Benthic Macroinvertebrate Index (MI)	Core Water Parameters (CWP)	Flow (F)	Water Level (WL)	Stream Geomorphology (SGM)	Watershed / Riparian / Stream Morphology (WRSM)	Physical Habitat Index (PHI)	Land Cover / Land Use (LC/LU)	Creel Census (CC)	Chlorophyl A (ChlorA)	Silica (Si)	Groundwater Level (GWL)	Precipitation / Well Level (PCW)	Sediment (S)	Sediment Accumulation (SA)	Specialized Water Chemistry Parameters (SWCP)
	Wildlife behavior disruption						X	X													
Riparian zone / floodplain																					
	Flow regime		X								X		X				X				
	Runoff – nutrients		X								X		X								
	Runoff – toxics		X								X		X								
	Runoff – sediments		X								X		X							X	
	Runoff - acid deposition (pH)		X								X		X								
	Habitat alteration		X								X		X				X				
	Deforestation		X								X		X				X				
	Non-native species		X								X		X				X				
	Trampling/compaction		X								X						X				
	Wildlife behavior disruption		X								X		X								

NCN Water Resource Monitoring Goal:

Establish a long-term program to monitor indicators of stressors impacting aquatic ecosystems to detect changes in the quality of the region's water resources:

a. to make better informed management decisions
b. to provide early warning of abnormal conditions
c. to provide data for comparison and building understanding of ecosystems
d. to provide data to meet legal and legislative mandates
e. to measure progress toward performance

NCN Water Resource Monitoring Objectives:
Establish status and trends of X vital signs at Y waterbody(ies) at Z times per year.

Specific X, Y, and Z depend on the protocols. It is anticipated that more specific objectives will be developed for each indicator that will be monitored.

Next Steps:

It is not feasible, within existing budgetary and manpower constraints, to collect data for every indicator listed in Table 15. Level of priority for these indicators must be determined so that funding can be applied as it becomes available. WRD provides additional guidance for determining monitoring priorities: "Beyond the required data set of core parameters and associated site metadata there should be a two-tiered focus, or a hierarchy, oriented toward monitoring the more significant waterbodies of a Network under two broad categories":

> <u>Category 1 Sites:</u> Outstanding Natural Resource Waters (designated under provisions of the Clean Water Act (CWA)). While the CWA is a Federal program, use standards and numeric criteria are predominately established or adopted from EPA by individual states. Thus, following state monitoring protocols are a fundamental basis of operation within the CWA regulatory context (*Draft Recommendations for Core Water Quality Monitoring Parameters and Other Key Elements of the NPS Vital Signs Program Water Quality Monitoring Component*, Freshwater Workgroup Subcommittee, June 14, 2002, Fort Collins, Colorado).
>
> <u>Category 2 Sites:</u> All other <u>significant waterbodies</u> that 1) have established threats or Network-identified stressors, 2) are subject to some ecological impairment or anticipated future impairment, 3) have no established baseline condition, or 4) are an aquatic resource with another Vital Sign tie-in having water column measurement needs to support biological monitoring (e.g. alkalinity water column monitoring tied to air monitoring of acid deposition having potential impacts to aquatic biota). Such parameters (what parameters??)(or suites of parameters--physical, chemical or biological) would be selected by Networks to document changes (improvement or further degradation) in water quality related to specific region, area, or site concerns/stressors (*Draft Recommendations for Core Water Quality Monitoring Parameters and Other Key Elements of the NPS Vital Signs Program Water Quality Monitoring Component*, Freshwater Workgroup Subcommittee, June 14, 2002, Fort Collins, Colorado).

The water workgroup plans to meet again in the fall to:

1. Review threats and resources identified by NPS personnel, state requirements and protocols for water monitoring, outstanding and impaired waters listings, and other sampling/monitoring efforts with which to partner (and also identify what is not being covered). This will be the basis of the prioritization to determine what indicators should be monitored. Specific objectives will then be created for each of those indicators.

2. Identify protocols based on state and national methods that can be used to monitor indicators to meet monitoring goals and objectives.

3. Identify collaborative approaches to implement monitoring.

Facilitator: Marian Norris, NPS/NCR - Center for Urban Ecology

Participants: Ray Chaput, Dave Eckert, Don Kelso, Annette Mills, Richard Orr, Rich Raesly, Susan Rivers, Gary Rosenlieb, Jim Voigt, Holly Weyers, and Bill Yeaman.

H. Wildlife Workgroup

The workgroup reviewed the conceptual model developed previously by the Science Advisory Committee (Appendix D). Note that fish were considered in the original model but were later assigned to the water resources workgroup.

Participants at the monitoring workshop simplified the conceptual model to show relationships among stressors, biological resources (taxa), and vital signs (Figure 2). The arrows between stressors and biological resources (taxa) were not meant to be exhaustive. Rather, the subject matter experts drew lines between stressors and the taxa that would be most sensitive to (or indicative of) a particular stress and that were most feasible to monitor. Land use change, for example, affects all resources but subject matter experts believed that assemblages with large home ranges would be most sensitive because they range outside of the parks where land use change are the most pronounced. Large mammals (e.g., bear) and possibly medium mammals (weasels, raccoons, etc.) would be important indicators to such changes. Taking cost-effectiveness into consideration, however, the experts agreed that birds would be a better indicator of land use change. Global warming was also believed to affect all resources but little information is currently available about this future threat.

Vital Signs and Monitoring Goals and Objectives

Potential vital signs were identified for taxa by brainstorming. Instead of prioritizing threats using the prioritization matrix, the workgroup prioritized vital signs using the same criteria. Goals and objectives were written by the workgroup for the four highest priority vital signs. The bullet points listed under the objectives are items or issues that the workshop participants felt should be considered when adaptive management objectives are created. In order for such objectives to be effective they need to be created with input from those who will be implementing them (i.e. the resource managers).

#1. Amphibian Composition

Goal: Monitor amphibians in the regional network.

Objectives:

- Coordinate with ARMI program
- Consider size stages to determine population structure (index of recruitment)
- Focus on streams (duskys, spring, two-lined) and ponds (mole salamanders, ramids, frog hybrids, toads)
- Information on species richness, abundance (percentage area occupied), age/size, structure
- Consider road kill data as potential information sources

Discussion: It was noted that amphibian monitoring was a high priority in part because of their importance as indicators on a world-wide scale. Population declines have been noted in many parts of the world. The causes for declines, however, are poorly understood.

#2. Deer

Goal: Monitor deer in the regional network.

Objectives:

- Refer to regional deer monitoring procedure which are still being developed
- Suggest peer review
- Coordinate with other regional deer information (state agencies)

  Discussion: Deer ranked high because of their significant impacts on the spread of exotic species, prevention of tree regeneration, and impacts to small mammal, amphibian, and bird populations.

#3. Land Birds (Passerines)

Goal: Monitor land birds in the regional network.

Objectives:

- Coordinate with national I & M bird monitoring protocol
- Refer to monitoring protocol in use at C & O Canal and others in region
- Consider taxa not included in standard research (i.e. nocturnal), taxa with specialized habitat, and migratory phrenology
- Coordinate with other regional studies

  Discussion: Birds ranked high in part because they are easy to monitor and standard protocols are widely used. In addition, their habitat associations are generally well understood so that they can be used as indicators of habitat change.

#4. Amphibian Disease

Goal: Monitor the prevalence and incidence of disease in amphibians within the regional network.

Objectives:

- Surveillance of malformation, chytrdidio mycosis, and iridiobirus
- Monitor in conjunction with population surveys
- Review current protocols

  Discussion: It was believed that the incidence of disease would be a useful indicator of atmospheric problems and land use changes in the region. This monitoring program would be done in conjunction with goal #1 above. Protocols could include the Australian disease protocols.

Additional Discussion

A fifth goal of monitoring small mammals as indicators of local forest and grassland health was proposed, but discussion was not resolved.

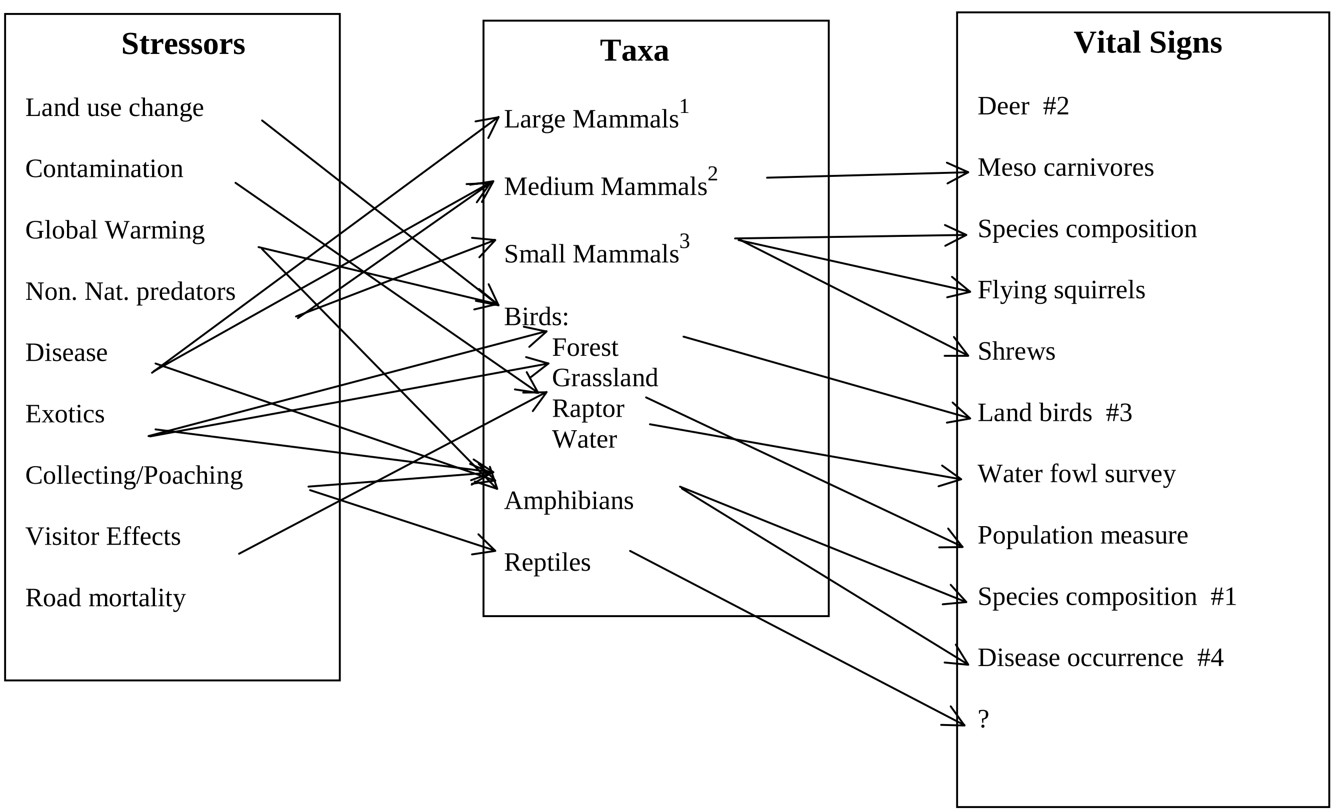
1. Wildlife monitoring needs to include rigorous taxonomic annual training to ensure accurate science.
2. Analyze data on human demographic and economic trends.

3. Climate change could be important for air, water, vegetation, geology, wildlife, etc., but the potential impacts are not yet understood. Comparative analyses should be considered. Weather data and climate change information is probably being collected already.

Facilitator: Glyn Thomas, Avatar, Inc.

Participants: Andrew Banasik, Scott Bates, Joe Ferris, Ed Gates, Jeff Hatfield, Juliet Healy, Jennifer Lee, Bob Lunsford, Duane Marcus, Bill McShea, Carrie, O'Brian, Allan O'Connell, Thomas Pauley, John Sauer, Jonathan Sleeman, Craig Snyder, and David Trauger

Figure 2. Wildlife conceptual model (revised)



[1] Large mammals includes only deer. There are not enough bear or cougar, nor large enough parks in the NCN, for serious monitoring.

[2] Medium mammals include mesocarnivores (e.g. fox, mustelids, including weasels, skunk, raccoon, opossum, squirrel, beaver, and river otter).

[3] Small mammals include mice, moles, and shrews.

Networking Opportunity

This session at the end of day two allowed individuals to raise topics for informal discussions. Topics related to monitoring or personal research interest were introduced to all the participants. Those interested in discussions were then gathered in small groups scattered throughout the auditorium. Notes were not kept on discussions.

Facilitator: Sue Thomas, Avatar, Inc.

Building a Collaborative Approach

The final session of the workshop allowed workshop participants to review and provide input to goals and objectives developed by the other workgroups. Each workgroup presented a poster highlighting goals and objectives or summaries of work completed during the workshop. Participants were asked to leave notes or comments on the posters or to engage group leaders and facilitators posted at each poster in a discussion. Results of this session were integrated into the workgroup summaries presented above.

Facilitator: Sue Thomas, Avatar, Inc.

Conclusions and Next Steps

Ellen Gray thanked everyone for their participation. Next steps will be for the I & M staff to generate a Monitoring Workshop Report (this document) and circulate it widely for additional input. The staff will also complete the Phase I Monitoring Plan and submit it to the Natural Resources Information Division. The SAC is expected to meet during fall/winter 2002/2003 to develop priorities among the vital signs identified by the workgroups at this workshop.

APPENDICES

Appendix A. Agenda

**NATIONAL PARK SERVICE MONITORING WORKSHOP:
PLANNING FOR THE FUTURE IN THE
NATIONAL CAPITAL REGION**

9-11 July, 2002

National Conservation Training Center, Shepherdstown, WV

Purpose of meeting: Continue the development of an integrated and comprehensive long-term Monitoring Plan for the National Capital Region of the National Park Service that provides essential information needed to preserve and enhance the region's most important natural resources.

Expected Outcomes: As a result of the meeting, we will:

(1) create a network of stakeholders (including park divisions, educational institutions, and other agencies) united to preserve the most important resources in the National Capital Region

(2) review technical information developed by the Science Advisory Committee to lead to the development of a long-term monitoring plan of the region's most important resources.
Specifically, we will:

(a) identify major threats (stressors and their sources) and their ecological effects to each important natural resource within the National Capital Region
(b) identify ecological indicators to monitor important resources and their threats
(c) develop priority monitoring objectives in line with monitoring goals guiding the National Park Service Inventory and Monitoring Program
(d) identify protocols that could be used to monitor indicators
(e) identify collaborative approaches to implement monitoring.

Tuesday - 9 July 02 (Day 1): Note all activities will be in the **Byrd Auditorium** unless indicated otherwise.

9:00 Registration and Coffee & Snacks **(Entry)**

10:00 Welcome and Introductions

10:20 Jim Sherald: A Milestone for the National Park Service.

10:30 Steve Fancy: The National Park Service Inventory and Monitoring Program – how is this program relevant to the parks?

11:00 Ellen Gray: Overview - The National Capital Region I & M Program

11:30 Larry Morse: The National Capital Region – a biological treasure chest

12:30 Lunch

1:45 Breakout Sessions Introduced

2:00 Concurrent breakout sessions.

Topic 1. Managing the Parks: using sound science to support park operations.

The Inventory and Monitoring Program is directed to provide relevant information to park managers. A presentation will focus on the information that is being developed by the Inventory and Monitoring Program. A discussion will follow exploring the utility of the information and how applied science and long-term monitoring can support park operations. **Instructional East - Room 103**

Topic 2. Monitoring Natural Resources through Partnerships:

A presentation will highlight the products being developed by the Inventory and Monitoring Program. A discussion will explore the need to enhance existing or develop new partnerships among scientists, land managers, and the Inventory and Monitoring Program to ensure that the region's most critical resources are being adequately monitored using rigorous protocols and can be protected. **Auditorium**

Topic 3. Interpreting the Region's Natural Resources

The National Park Service has a long-standing tradition of interpreting the park's and the region's natural resources. A presentation will highlight the information being developed by the Inventory and Monitoring program. A discussion will focus on how this information could be used to support interpretation and education programs to enhance the public's understanding of the region's natural resources. Additional information needs will be explored. **Instructional East - Room 201**

4:00 Defining our role in resource protection in the National Capital Region.

5:00 Adjourn

7:00 Evening Social: Grand Prize Drawing and Live Music - Nick Blanton and Paul Oorts will play a mix of traditional Celtic and Continental music.

Wednesday - 10 July 02 (Day 2). Note: all activities will be in the **Byrd Auditorium** unless indicated otherwise.

7:00 Registration **(Entry)**

8:00 Welcome and Today's Overview

8:15 Mikaila Milton: Introduction to the Science Advisory Committee and Today's Outcomes.

8:30 Steve Fancy: What are Vital Sign Indicators

9:00 Thematic breakout sessions to reviews threats, ecological effects, and potential ecological indicators.

Topic 1. Air. **Instructional East - Room 113**

Topic 2. Geology. **Instructional West - Room 155.**

Topic 3. Invertebrates. **Instructional East - Room 109.**

Topic 4. Landscape. **Instructional West - Room 124.**

Topic 5. Rare, Threatened, and Endangered Species/Communities. **Instructional East - Room 118.**

Topic 6. Vegetation Communities. **Instructional East - Room 201.**

Topic 7. Water. **Instructional East - Room 112.**

Topic 8. Wildlife. **Instructional East - Room 103.**

12:00 Lunch

1:00 Wendy Cass: Setting Monitoring Goals and Objectives

1:45 Continue Thematic Breakouts. **(See locations assigned above).**

4:00 Networking Opportunity

5:00 Adjourn

7:30 Stephanie Flack: The Potomac Gorge: Collaborative planning to preserve the region's most biologically diverse site.

Thursday - 11 July 02 (Day 3). Note: all activities will be in the **Byrd Auditorium** unless indicated otherwise.

8:00 Checkout of your rooms

8:30 Overview

9:00 Thematic Breakout Session Continued. **(See locations assigned above).**

12:00 Lunch

1:30 Building a Collaborative Approach.

3:00 Wrap – up. Identify next tasks.

3:30 Adjourn

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Appendix C. List of handouts for Monitoring Workshop

The following handouts were provided to all SAC and Monitoring Workshop participants. They are available on NCR I & M Website: http://www.nature.nps.gov/im/units/nw12/monitoringworkshop.html)

1. Monitoring Workshop AGENDA (PDF).

2. CURRENT MONITORING IN NCR (PDF) Summarizes monitoring efforts conducted in the vicinity of the National Capitol Region. See Park Summaries below for summaries of monitoring efforts within the National parks.

3. NCR COMMUNITIES (EXCEL) The spreadsheet with multiple tabs lists species of concern along with their ranks, threatened and endangered species, major cover types, and significant habitats identified by heritage programs at each national park in the NCR. A list of expected communities associations in the NCR is also provided.

4. PARK SUMMARIES (PDF) Summarizes natural resources, management issues, and ongoing monitoring efforts for each national park in the National Capital Region. Also see the summary table below.

5. SUMMARY TABLE (EXCEL) Excel spreadsheet which documents monitoring efforts identified in the park summaries above.

6. PRIORITIZATION TABLE (PDF) Worksheet to establish monitoring priorities for the National Capital Region. .

7. SAC TABLE (EXCEL) Conceptual model developed by the Science Advisory Committee to describe the threats, sources of threats, severity, resource component affected, potential vital signs, and monitoring protocols for each important resource identified in the National Capital Region. The resources include Air, Water (see also supplemental information provided on the water tab), Invertebrates, Vegetation Communities, Landscape, Wildlife, Geology, and Rare – Threatened & Endangered Species (note RTE tab on the spreadsheet). This table will be the focus of thematic breakout sessions on 10-11 July SAC TABLE DEFINITIONS (PDF). **See also Appendix D below.**

Appendix D. Draft Conceptual Model Developed by SAC before Monitoring Workshop.

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Air	I. Physical - presence of solids and aerosols in the atmosphere, temperature, UV, humidity	a. Wet/dry acidic deposition, b. Ozone	Natural: a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic: a. Stationary (smokestack) utilities and industries, b. Mobile (planes, trains, and auto-mobiles), c. Area (i.e. rock quarries)	a. Biodiversity (terrestrial and aquatic), b. Material and monument degradation, c. Health (increased biogenic emissions such as ozone precursors), d. Hydrologic, e. Geologic, f. Increased energy use (pollutants), g. Weather changes-rainfall shadow	Low to medium	NADP (exists all around you), ozone (networks exist), monument degradation (photograph periodically)		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Air	IA. Visibility - how far, how well you can see - regional haze	Particulates, aerosols	Natural: a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic: a. Stationary (smokestack) utilities and industries, urban rainshadow, b. Mobile (planes, trains, and auto-mobiles), c. Area - small sources such as dry cleaners and rock quarries	Human perception, health of terrestrial living beings	Medium due to severity of numbers of people here	Instrumentation (camera, nephelometer, line of sight), anecdotal (historical reference), socio-surveys (exit interviews to assess human perception - GRCA, SERI)		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Air	IB. Precipitation volume (rain, snow, cloudwater)	Volume	Natural: a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic: a. Stationary (smokestack) utilities and industries, b. Mobile (planes, trains, and auto-mobiles), c. Area (i.e. rock quarries)	Flood & erosion, or drought; cultural-natural interface	Low most of the time, could be intermittently high	USGS river gauges for stream volume, National Weather Service local weather		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Air	IC. Climate	UVB, Urban Heat Island	Natural: a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic: a. Stationary (smokestack) utilities and industries, b. Mobile (planes, trains, and auto-mobiles), c. Area (i.e. rock quarries)	Weather changes - rainfall shadow	Low	UVB - instrumentation (very expensive), biomarkers (list of ozone sensitive plants and amphibians), genomic technologies to test sensitivity, Urban Heat Island - data exists, fire weather (high/low temps, etc.), remote sensing data $10m^2$ available free from NOAA and NASA		(Vegetation and Wildlife)

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Air	II. Chemical - elements and compounds that interact with air and lead to effects	a. Nitrogen, b. Sulfur, c. Metals (i.e. mercury), d. Ozone, e. PM(10) & PM(2.5), f. Greenhouse gasses, g. Hydrogen ion deposition, h. Air toxics	Natural: a. Wind blown geological crust, b. Volcanoes, c. Aerosols, d. Fire Anthropogenic: a. Stationary (smokestack) utilities and industries, b. Mobile (planes, trains, and auto-mobiles), c. Area (i.e. rock quarries)	a. Biodiversity (terrestrial and aquatic), b. Terrestrial and aquatic eutrophication, c. Terrestrial and aquatic acidification, d. Toxicity affects-bioaccumulation, e. Material and monument degradation, f. Vegetation impacts, g. Climate change, h. Geographical shifts, i. Hydrology, j. Pest populations, k. Human health	Ranges high to low - intermittent, and depends on chemical	Ambient air monitoring networks exist		(Wildlife)
Geology	Coastal Areas	Impervious Surfaces	Rip rap, armoring, coastal walls, dredging	Changes in water flow rates, unnatural erosion and deposition, changes in natural shoreline, changes in sedimentation	High - locally	Sedimentation coring (deep cores=research, shallow cores=monitoring), mapping of shoreline change, use of Pope's Creek as a reference area		(Water)

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Geology	Exposed rock	Cutting the toe of slopes, over-steepened slopes, dipslopes	Development, roads, structures, trails, flooding, vegetation death (hemlock, etc.), logging	Reduced slope stability	Low	Slope failure, reduced slope stability, movement of materials downslope, erosion, gully formation		
Geology	Groundwater	Consumption of groundwater in excess of replenishment	Human, agricultural, residential, commercial use and domestic animal use	Reduced groundwater quantity and quality; loss of springs and seeps, wetland loss, change of soil saturation zones	High	Survey of groundwater table and groundwater chemistry; groundwater flow monitoring wells		Water
Geology	Groundwater	Introduction of toxics	Landfills, abandoned mines, land engineering	Reduced groundwater quality	High	Groundwater monitoring wells		Water
Geology	Groundwater	Physical failure	Landfills, abandoned mines, land engineering	Change in subsurface water flow patterns, change in subsurface temperatures, introduction of contaminants	High	Groundwater monitoring wells (flow and mapping), subsurface temperature changes		Water

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Geology	Groundwater	Water bypasses the soil profile	Old / abandoned wells (farms)	Increased groundwater contamination	Unknown	Groundwater monitoring and monitoring of these abandoned wells (which could serve as monitoring sites in general). Wells need to be found and sealed to minimize contamination.		Water
Geology	Groundwater	Impervious Surfaces	Roads, buildings, infrastructure	Reduced water infiltration leading to reduced groundwater recharge, movement of water between watersheds	Medium	Map and monitor groundwater recharge areas, monitor groundwater table levels and chemistry, subsurface temperature monitoring.		Water
Geology	Karst	Toxics: pesticides, dumping, spills	Agriculture, septic systems, sewage, dumping, industry, spills	Rapid movement of contaminants to ground water, change in ground water chemistry and resulting change in biology	High - locally	Subterranean invertebrates, ground water chemistry/quality		Water

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Geology	Karst	Nutrient Loading	Agriculture, septic systems, sewage, dumping, industry, spills	Rapid movement of nutrients to ground water resulting in change to ground water quality and change in biology	High - locally	Subterranean invertebrates, ground water nutrient content		Water (Invertebrates)
Geology	Karst	Structural collapse, sinkholes	Inappropriate construction practices, dissolution in karst areas	Change in biology due to changes in air flow and temperature, volume and flow of water increased in areas of dissolution of bedrock	High - locally	Change in sinkhole size, aerial photos to capture surface changes, subsurface temperature monitoring		
Geology	Lakes, ponds, seeps, vernal pools	Nutrient loading	Agriculture, residential lawn care, vegetation change	Eutrophication, change in fauna (esp. herps), effect upon T&E species	Unknown	Size/volume, chemistry, and temperature of surface water component		Water
Geology	Lakes, ponds, seeps, vernal pools	Pesticide loading	Agriculture, residential, and commercial use	Addition of herbicides and pesticides to surface water, change in fauna, effect upon T&E species	Unknown	Pesticide, herbicide content of surface water component		Water
Geology	Riparian areas, wetlands	Change in soil surface elevation and horizontal dimensions	Land engineering resulting in changes to deposition and erosion, dredging, dumping, creation of impoundments and dams	Disruption to the wetland/riparian ecosystems, change in storm water flow rates, vegetation change, wildlife change, change in stream bed characteristics	High	High resolution riparian/wetland elevation monitoring, vegetation monitoring, sediment budget, changes in size of wetland area		(Landscape and Vegetation)

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Geology	Soil	Pesticide loading	Agricultural, residential, and commercial use	Accumulation of pesticides that adhere to soil particles, causing changes to or the elimination of non-target soil fauna populations	High	Test soils and sediment for suite of pesticides commonly used in local area; lithogeochemical studies (USGS)		
Geology	Soil	Nutrient loading	Agricultural, residential and commercial use	Acidification of the soil, reduction of soil organic matter, change in soil fertility status	High	Soil pH, soil N and P status, soil organic matter levels, lithogeochemical studies (USGS)		
Geology	Soil	Change in pH, loss of buffering capacity	Acid rain, atmospheric deposition	Change in vegetation types, mycorrhiza and other soil flora, fauna	Unknown	Soil pH, acid-neutralizing capacity, mass flow/hydrologic modeling (ANC), lithogeochemical studies (USGS)		
Geology	Soil	Temperature change	Climate change	Changes in soil micro-climate	Unknown/locally high	Soil temperature /moisture monitoring, changes in soil flora, fauna and mycorrhiza suite		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Geology	Soil	Erosion	Development, land clearing, increasing impervious surface	Increased siltation, reduced productivity/ health/abundance of soil, plants, and aquatic organisms	High	Total suspended solids, sediment loading, light penetration, increased sedimentation and changes in sedimentation patterns, land use change		Water
Geology	Soil	Change in vegetation/exotics	Development, nursery use of exotics	Change in soil organic matter composition, changes in soil flora and fauna, pH, nitrification rates	Unknown	Exotic species monitoring and control measures, soil chemistry, soil organic matter levels, soil pH, soil nitrification rates		(Vegetation)
Geology	Soil	Fill dirt: complete changes in soil physical and chemical composition resulting from filling in land areas with soil from another location (esp. DC)	Landfills, abandoned mines, land engineering	Changed or destroyed soil profile, change in chemical composition of soil, introduction of toxics, introduction of impervious structures to soil profile, compaction	High – esp. urban	Complete change or loss of soil profile, mass balance (incoming chemistry - outgoing chemistry), change in subsurface temperatures, change in land surface elevation profile, movement of physical debris from land, soil compaction		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Geology	Soil	Compaction	Visitor use	Changes in vegetation survival, changes in soil physical properties	Urban/locally - high	Monitor soil compaction, bulk density, porosity, or other soil compaction measures		(Vegetation)
Geology	Soil	Impervious surfaces	Paving, walls, armored banks	Scouring, cutting/changing shoreline, flooding,	High	Increased velocity of storm water flow, land use change		(Landscape and Water)
Geology	Soil/surficial factors	Erosion	Development	Change in “normal” sedimentation sequence and composition	Unknown/low	Coring of soil/sediment sequence		
Geology	Soil/surficial factors	Clearing of land	Soil surface exposure, development, agriculture, zoning laws (local and county governments)	Loss of soil surface cover, increased soil surface and groundwater temperatures	High	Measurement of soil surface and groundwater temperature, monitoring of bare soils in region		Landscape and Water
Geology	Surface water	Impervious surfaces	Infrastructure, development, residential and agricultural use, rip rap, armoring etc.	Increased storm water flow, increased erosion, changes in stream morphology, increased exposure to nutrients/pesticides, change in hydrologic cycle effecting floodplains, and floodplain/riparian buffer capacity, change in base flow	High	Stream storm water flow, flood frequency, sedimentation load, stream morphology, photo points, storm event sampling, mass flow/ hydrologic modeling		Landscape and Water

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Geology	Surface water	Pesticide loading	Agricultural, residential, and commercial use	Reduced water quality, fishery health, and aquatic invertebrate communities and populations	High	Test for suite of pesticides commonly used in local area		Water
Geology	Surface water	Nutrient loading	Agricultural, residential and commercial use	Reduced water quality, fishery health, and aquatic invertebrate communities and populations. Algal blooms, eutrophication	High	Soil water and stream levels of N and P, high algal growth, low light penetration		Water
Geology	Unique soils: calcareous and serpentine soils	Lack of information for these soils and soil in general		Potential for damage to unknown/ unmapped resource	Unknown	Complete, up-to-date, high resolution soil maps		
Invertebrates		Air quality	Ground level ozone	Cell damage	Inconclusive			
Invertebrates		Air quality	Chemicals	Mortality and sublethal effects	Unknown			
Invertebrates		Air quality	Chemicals	Habitat change	Unknown			
Invertebrates		Water quality	Chemical	Direct mortality	Variable			Water
Invertebrates		Pest management (pesticide use, including lawn care, forest pest management, other)						
Invertebrates		Drought	Natural	Various: habitat modification and direct mortality	Variable			
Invertebrates		Drought	Anthropogenic	Various: habitat modification and direct mortality	Variable			

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Invertebrates		Global warming						
Invertebrates		Flooding	Natural	Various	Variable			
Invertebrates		Flooding	Anthropogenic	Various	Variable			
Invertebrates		Landscape modifications	Human	Habitat change / loss	Variable			
Invertebrates		Landscape modifications	Human	Habitat change / loss	Variable			
Invertebrates		Urban sprawl - roads (new)						
Invertebrates		Urban sprawl - road design						
Invertebrates		Urban sprawl - road maintenance (sand/salt)						
Invertebrates		Urban sprawl - road use						
Invertebrates		Urban sprawl - heat island effect						
Invertebrates		Urban sprawl - light (artificial)						
Invertebrates		Urban sprawl - humidity						
Invertebrates		Urbanization	Natural	Various				
Invertebrates		Deforestation						
Invertebrates		Fire (lack of natural fire regime)						
Invertebrates		Loss of stream habitat						
Invertebrates		Water Quality	Sediment	Habitat change	Variable			

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Invertebrates		Exotic Species - insects (Asian lady beetle, Asian longhorn beetle, gypsy moth, Hemlock W. Adelgid)						Vegetation look at effects on vegetation
Invertebrates		Exotic Species - pathogens (non-native including fungi [Dutch elm], bacteria, other).						Vegetation look at effects on vegetation
Invertebrates		Exotic species - plants (invasive)						Vegetation look at effects on vegetation
Invertebrates		Exotic species – plants; other harmful plants (pathogens, pollinator stealers)						Vegetation look at effects on vegetation
Invertebrates		Exotic species - vertebrates (perhaps birds, mammals, fish, reptiles)						
Invertebrates		Exotic species - other inverts (zebra mussel, earthworm)						
Invertebrates		Noise pollution						
Invertebrates		Recreation (impact to water surface conditions which impact egg-laying)						Water
Invertebrates		Collecting						
Invertebrates		Human population growth						

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Invertebrates		Soil disturbance (artificial such as change to stream bottoms, lake bottoms, etc.)						
Invertebrates		Agriculture (GMO)						
Landscape	Corridors	Land use practices	Any development	Habitat fragmentation, increase in exotics, increase in edge.	High	Connectivity of habitat of interest; riparian buffers		
Landscape	Forest interior habitat	Habitat fragmentation / amount of edge	Any development	Loss of habitat and species through habitat degradation	High	Bird community index; amount of forest interior habitat		
Landscape	Habitat structure (contagion and configuration)	Habitat fragmentation / amount of edge	Altered disturbance regime	Habitat degradation, loss of species and ecosystem functions	High / Medium	Quantify contagion and connectivity for habitats of interest		
Landscape	Habitat structure (type, shape, and configuration)	Exotics	Altered Disturbance Regime	Habitat degradation, loss of species and ecosystem functions	Low	Quantify fragment size distribution and perimeter: area ratios for habitats of interest.		
Landscape	Habitat structure (type, shape, and configuration)	Species over-abundance	Altered disturbance regime	Habitat degradation, loss of species and ecosystem functions	Low	Quantify habitats of interest (map and analyze habitats of interest for structure and composition); density of species of interest.		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Landscape	Habitat transition zones (edge)	Land use practices	Any development	Loss of habitat and species	Low	Quantify soft edge and early successional habitat vs. hard edge; riparian buffers (map)		
Landscape	Landscape matrix (greater landscape)	Fragmentation of decision making	Legislation	Altered ecosystem structure and function	High	Juxtaposition of legislative jurisdictions (mapping jurisdictions); juxtaposition of zoning intensities		
Landscape	Species-specific natural habitats	Land use practices	Land use	Change of habitat availability	High	Change in % of any species-specific habitat; Bird Community Index; % of impervious surfaces		
Landscape	Species-specific natural habitats	Land use practices	Land use	Change in species	High	Presence and absence of particular species / taxa		
Landscape	Total forest habitat	Land use practices	Land use	Deforestation	High	% forest cover; Bird Community Index; riparian buffers		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Landscape	Total forest habitat	Land use practices	Land use	Altered rates of nutrient export	High	Bird Community Index; % agriculture at low topographic (slope) positions; amount of impervious surface		
Vegetation Community	Aging hardwoods (e.g. oak, hickory), lichens, conifers	Air pollution (including ozone and acid deposition); increase CO_2 and N (human-caused)	Power plant and car emissions	Increased incidence of decline of some species; disease (multiple stress effect), increased vegetation growth (CO_2 and N)	Medium	Lichens: cover, community composition, pollutant levels in lichens, tree health (a lichen survey is needed.)	Plots for lichen cover and species composition (lichen survey needed)	
Vegetation Community	All contiguous vegetation cover types	Disturbance - fragmentation	Changes in land use inside & outside parks, park legislation and management	Increased amount of edge, increased non-native plants, decrease in population size viability	Medium/High	aerial photography over time	Aerial photos yearly	(Landscape)
Vegetation Community	All types, forests, wetlands, meadows, scrub/ shrub	Non-native plants	Accidental & deliberate introduction, horticulture, land use disturbances, dumping, animals	Displacement of native plants, changes in hydrology, changes in soil chemistry, wildlife habitat loss	High	Community composition	Protocols for plots (Sue S.)	

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Vegetation Community	All vegetation communities	Disturbance - catastrophic **(natural)**	Hurricane, tornado, river flooding, ice storm, strong wind, landslides, fire	Soil saturation, biomass loss(limb breakage, defoliation, removal of above-ground portion), soil loss around roots, increase light (from canopy), decreased light (heavy layer of dead and down wood), canopy loss, understory loss, gap creation, increase seed distribution, loss of seed bank, erosion, change in species diversity, change in species composition, increase in non-native species, increase forage for wildlife, loss of wildlife habitat	Low to medium	Community composition over time		(Landscape)
Vegetation Community	All vegetation communities	Cultural resources	Overlapping & conflicting legislation	Fragmentation, habitat changes, introduction of chemicals, increase in exotics, change in natural species composition.	Medium/high		Cover and extent of exotic plants at cultural sites over time--compare with other non-cultural areas	

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Vegetation Community	All vegetation communities, especially rare or sensitive species	Overuse & concentrated use, poaching, littering	Visitors	Soil compaction, trampling of plants, population decline of rare plants, increase in non-natives.	Medium		Vegetation cover, extent of social trails over time, amt of litter over time	(RTE)
Vegetation Community	All vegetation communities, soil, water quality	Development - external (non-NPS, outside boundaries)	Commercial, residential, utilities	Wildlife habitat fragmentation, changes in hydrology, increase in non-native species, erosion, loss of vegetation and change in species composition	High		Community composition from the developed edge inward, wetlands extent and water level	
Vegetation Community	All vegetation communities, soil, water quality	Development - internal (NPS & others, inside park boundaries)	New facilities, concessions, politics, utilities, maintenance	Wildlife habitat fragmentation, changes in hydrology, increase in non-native species, erosion, wetland drainage loss of vegetation and change in species composition	High		Community composition from the developed edge inward, wetlands extent and water level	(Landscape is looking at large scale fragmentation)
Vegetation Community	American beech	**Tree diseases**, beech bark disease	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed	Low, all tree diseases together medium	Tree health and population size		(Invertebrates)
Vegetation Community	American chestnut	**Tree diseases**, chestnut blight	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed	Low, all tree diseases together medium	Tree health and population size		(Invertebrates)

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Vegetation Community	American elm, other elms?	**Tree diseases**, Dutch elm disease	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed	Low, all tree diseases together medium	Tree health and population size		(Invertebrates)
Vegetation Community	Butternut	**Tree diseases**, butternut canker	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed	Low, all tree diseases together medium	Tree health and population size		(Invertebrates)
Vegetation Community	Flowering dogwood	**Tree diseases**, dogwood anthracnose	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed	Low, all tree diseases together medium	Tree health and population size		(Invertebrates)
Vegetation Community	Forest understory	White-tailed deer	Lack of predators, and increase in mature forest and edge habitat	Changes in natural species composition/cover, impedes/alters successional changes	High	Seedling regeneration, browseline, species composition	Exclosures, transects, age and class distribution of particular species, browse (line or amount)	
Vegetation Community	Hemlock	**Tree diseases**, non-native insect: hemlock wooly adelgid	Accidental & deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat	Medium	Tree health and population size		(Invertebrates)
Vegetation Community	Insect pollinated plant species, especially species specific to certain pollinators	Loss of native pollinators	Loss of habitat	decline in native species abundance, change in species composition, loss of habitat	Unknown	Individual species abundance--compare with historical abundance		(Invertebrates)

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Vegetation Community	Maple, elm	**Tree diseases**, non-native insects: Asian longhorn beetle	Accidental & deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat	Low	Tree health and population size		(Invertebrates)
Vegetation Community	Marshes	Non-native animals: nutria	Accidental & deliberate introduction	Trampling, grazing, changes in natural plant population sizes	Low			
Vegetation Community	Meadows, forest	Non-native animals: feral cats, dogs, rabbits	Accidental & deliberate introduction	Trampling, grazing, changes in natural plant population sizes, nutrient loading	Low	Vegetation cover and nutrient levels		
Vegetation Community	Native wetlands	Wetland mitigation (creation of new wetlands)	Installation of new facilities, utilities, infrastructure, concessions, maintenance	Hydrology, changes in species composition, displacement of native plants, habitat loss	High	Species composition of native vs. created wetlands over time		
Vegetation Community	Oaks, pine, other trees	**Tree diseases**, non-native insect: gypsy moth	Accidental & deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat	Medium	Tree health and population size		(Invertebrates)
Vegetation Community	Potentially all vegetation types, especially successional areas, grasslands and shrub habitat (seen as politically more expendable than forest)	Politics, greed, homocentricism, self promotion	Congress, NPS hierarchy, survival instinct	Loss of habitat, fragmentation	High	Politically affected management decisions	Number of politically mandated actions that affect the resource per year, including the number of times politics prevents the best management of resources	

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Vegetation Community	Riparian and aquatic vegetation	Erosion a (stream bank)	a- increased impervious surfaces within the watershed, flooding, boat wake (larger rivers), deforestation, agriculture, construction, recreation (vehicles, horseback riding, hikers)	a- destruction of stream bank, incising/lowering of stream, addition of sediment	Medium	Vegetation cover and change in sediment deposition		(Geology, Water)
Vegetation Community	Riparian and aquatic vegetation	Erosion b (stream channel)	b- construction, deforestation	b- uprooting of aquatic vegetation, sediment addition in wetland areas downstream	Medium	Bank height		(Geology, Water)
Vegetation Community	Riparian and aquatic vegetation	Erosion c (land surface)	c- culverts	c- removal of substrate and vegetation	Medium	Vegetation cover and soil loss		(Geology, Water)
Vegetation Community	Tree species composition	Climate Change	Power plant and car emissions, agriculture	Increasing: Sweetgum, Loblolly, S. Red Oak, Blackjack Oak, Post Oak, Winged Elm. Decreasing: Sugar Maple, Beech, White Ash, N. Red Oak	Medium	Community composition and species distribution		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Vegetation Community	Upland communities - fire; riparian, 1st and 2nd terrace communities--flood	Disturbance - changes to natural disturbance regimes (fire, flood)	Land use changes inside and outside parks--fire and flood; weather events drives all	Changes in natural species composition/ cover, successional changes may (flood) or may not (fire) be disturbance driven	Low	Historical analysis--accounts, pollen cores, phytoliths	Pollen cores in wetlands, phytoliths	
Water	Benthos, lentic, lotic	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Reduction in biodiversity, change in ratio of generalists to specialists, increase in tolerant species and decrease in intolerant species, increase in non-native species, increase in less desirable species				
Water	Benthos, lentic, lotic	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Reduction in biodiversity, change in ratio of generalists to specialists, increase in tolerant species and decrease in intolerant species, increase in non-native species, increase in less desirable species, population decline, change in community structure, disrupted age structure, decreased reproductive success		Macroinvertebrate index, physical habitat		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Water	Fish - historic (serve as a baseline) - current lifecycle	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption, overfishing/ harvesting/collecting	See Appendix C (SAC table – Water)	Reduction in biodiversity, change in ratio of generalists to specialists, increase in tolerant species and decrease in intolerant species, increase in non-native species, increase in less desirable species, fish kills, hybridization, decreased reproductive success, change in migration patterns or spawning time or location, disease/mutation rate increase, change in ratio of stenothermal and eurythermal species, population decline, disrupted age structure		Sedimentation, creel census, temperature, physical habitat, DO, macro-invertebrates, fish population, brook trout or other indicator species		
Water	Herps	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Reduction in biodiversity, change in ratio of generalists to specialists, increase in tolerant species and decrease in intolerant species, increase in non-native species, increase in less desirable species				(Wildlife for terrestrial herps)

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Water	Land-use / watershed	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Increased impairment of water quality, water supply, and physical habitat (i.e. algal blooms), including alteration of range and frequency of disturbance; decrease buffer / filter capacity				
Water	Physical habitat	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Scouring, bank instability/mass wasting, sedimentation, altered stream morphology, altered temperature regime, altered canopy cover		Stream geomorphology, sedimentation, assessment (EPA, etc.)		
Water	Plankton	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Increase in undesirable and non-native species, disruption in population cycle and size, change in biodiversity		Plankton population, nutrients		
Water	Precipitation		See Appendix C (SAC table – Water)	Decrease buffer / filter capacity				

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Water	Riparian zone / floodplain	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Increased impairment of water quality, water supply, and physical habitat (i.e. algal blooms), including alteration of range and frequency of disturbance; decrease buffer / filter capacity; change in vegetation community due to altered flooding regime		Assessment, aerial photography		
Water	Vegetation - wetlands, channel,	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Reduction in biodiversity, change in ratio of generalists to specialists, increase in tolerant species and decrease in intolerant species, increase in non-native species, increase in less desirable species, change in community structure, disease/ pest increase, decreased regeneration		Land cover in watershed, precipitation/wells, community structure, indicator species, sedimentation		(Vegetation)

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Water	Vernal/ ephemeral pools	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Change in number, timing, and presence of pools, decrease in herp reproductive success, reduction in biodiversity, increase in tolerant species and decrease in intolerant species, increase in non-native species, increase in less desirable species, change in community structure, diseased/pest increase, decreased regeneration		Number and size of pools, groundwater, amphipods, reproductive success of herps		
Water	Water quantity, quality - groundwater	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption	See Appendix C (SAC table – Water)	Increased impairment of water quality, water supply, and physical habitat (i.e. algal blooms), including alteration of range and frequency of disturbance; decrease buffer / filter capacity; decreased recreational opportunities (swimming, fishing, etc); aesthetics; altered biological communities		Flow, water quality, bacteria, toxics, water chemistry, nutrients, wells, groundwater level		

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Water	Waterfowl and shorebirds	Trash, flow regime, water quality, physical habitat, deforestation, energy cycle disruption, introduced species, climate change, wildlife behavior disruption, over-fishing/harvesting/ collecting	See Appendix C (SAC table – Water)	Disrupt breeding, change/prevent migration patterns, increase in disease, change in predation rates, altered community structure, change in biodiversity, increase in tolerant species and decrease in intolerant species, increase in hybridization, increase in non-native species and populations		Nesting, species composition, indicator species		Wildlife
Wildlife	Birds: Fids	Deer	Development and landscape changes	Decreased diversity, change or loss of habitat	High			
Wildlife	Birds: Fids and grassland birds	Development (cell towers, housing development, roads)	Land use and landscape changes	Habitat loss, fragmentation, increased mortality	High			
Wildlife	Birds: Fids, grassland birds, and waterfowl	Avian diseases	Exotics and population overcrowding	Mortality, decreased diversity	Unknown			
Wildlife	Birds: Fids, grassland birds, colonial waterbirds, and waterfowl	Predators	Human introduction and landscape changes	Mortality, decreased diversity	High – Medium			
Wildlife	Birds: FIDS, grassland birds, raptors	Habitat fragmentation and habitat loss	Development; management practices; natural processes	Habitat loss	High – Medium			

Workgroup	Resource Component	Stressor	Sources	Ecological Effects	Severity of Threat to Resource (Low - Med - High - Unk)	Indicator/ Vital Sign	Protocols	Lead workgroup on this issue, or assists if in parentheses
Wildlife	Birds: Fids, grassland birds, raptors	Succession	Natural processes	Habitat variation, change in food supply	Low			
Wildlife	Birds: Fids, grassland birds, raptors, colonial waterbirds, and waterfowl	Contaminants	Residential pesticides, roads (salts and petro. spills), industrial air pollution, water management practices	Increased mortality, decreased diversity, decreased repro-ductive rates, malformations	High – Medium			
Wildlife	Birds: Fids, grassland birds, raptors, colonial waterbirds, and waterfowl	Climatic variation	Global warming, El Nino/La Nina	Habitat variation, change in food supply,	High – Low			
Wildlife	Birds: Fids, grassland birds, raptors, colonial waterbirds, and waterfowl	Exotic and invasive species	Urbanization; transportation mechanisms (human, bird, air, water)	Habitat loss, decreased diversity, increased mortality, increased competition	Medium			
Wildlife	Fish	Chemical contaminants	Industry/human development	Water chemistry changes, decreased DO, habitat loss, increased disease, decreased reproduction, loss of diversity	High	Changes in water chemistry, pollution monitoring		
Wildlife	Fish	Habitat degradation	Industry/human development	Sedimentation, habitat loss or change, loss of diversity, population changes	Medium	Vegetation/water quality monitoring, changes in habitat makeup (loss of grasses, etc)		

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Wildlife	Fish	Increased disease levels	Contaminants	Population decrease, loss of diversity, loss of population viability	Medium	Increased levels of fish kill, increased occurrences of disease indicators in fish		
Wildlife	Fish	Exotic introduction	Commercial and noncommercial	Habitat loss, decreased reproduction, loss of diversity	Low	Decrease native populations, increase of exotic populations		
Wildlife	Fish	Competitor introduction	Humans, habitat changes	Habitat loss, decreased reproduction, loss of diversity	Low	Decrease native populations, increase of exotic populations		
Wildlife	Fish	Change in levels of fishing	Humans	Population decrease, loss of diversity and viability (genetic)	Medium	Decrease native populations, increase/decrease catch limits		
Wildlife	Fish	Fisheries management policies	Humans	Population changes, loss of diversity, overfishing the resource	Medium	Monitor new legislation		
Wildlife	Herps	Ozone Depletion	Industrial					
Wildlife	Herps	Contaminants	Development, industrial					
Wildlife	Herps	Droughts	Natural processes					
Wildlife	Herps	Fragmentation	Natural processes, development, park management					

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Wildlife	Herps	Road mortality	Development, park management					
Wildlife	Herps	Disease	Natural processes, human introduction					
Wildlife	Herps	Exotic species	Natural processes, park management, human introductions					
Wildlife	Herps	Illegal harvests	Human influence					
Wildlife	Herps	Predation	Natural processes					
Wildlife	Mammal	Contaminants	Development, industrial					
Wildlife	Mammal	Fragmentation	Natural processes, park management, development					
Wildlife	Mammal	Road mortality	Development, park management					
Wildlife	Mammal	Disease	Natural processes, human introduction					
Wildlife	Mammal	Predation	Natural processes					